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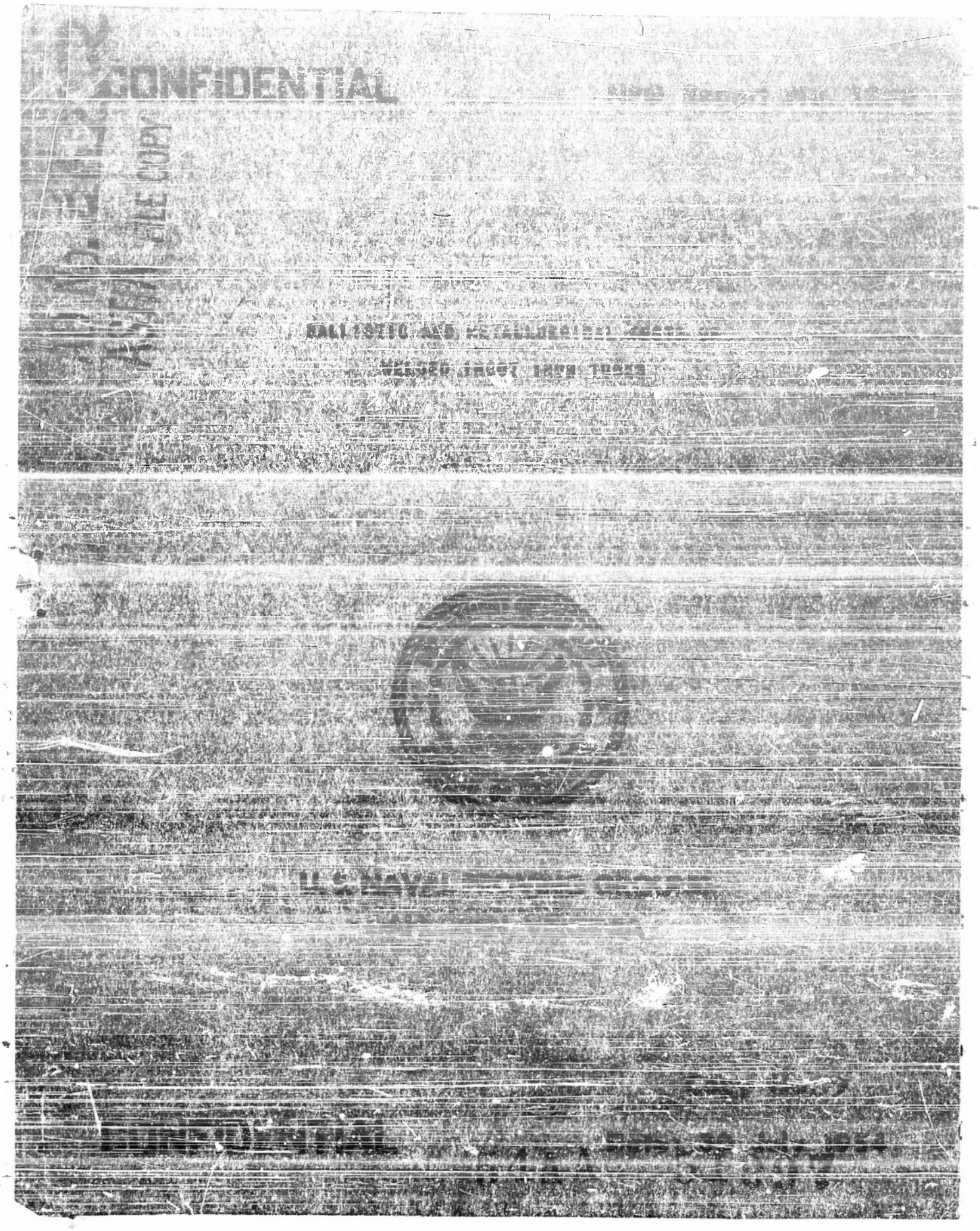

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U. S. Naval Proving Ground
Dahlgren, Virginia

Ballistic and Metallurgical Tests of Welded Ingot Iron Tubes

by

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and
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NPG REPORT NO. 1286

Task Assignment No.
NPG-Re3b-225-1-53

30 July 1954

APPROVED: J. F. BYRNE
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ABSTRACT

Before an adequate number of 3"/50 and 3"/70 projectiles could be obtained with ingot-iron bands for gun wear tests, a method of fabricating iron band blanks in quantity was needed. An investigation of the properties and performance of band blanks cut from welded tubing that had been formed from Armco iron plate stock is reported here. Four 3"/70 Projectiles Type Ex 24 Mod 11 and four 3"/50 Projectiles Type Ex 29 Mod 1 with iron bands fabricated by this method were fired for recovery along with comparison projectiles having iron bands machined from bar stock. A series of metallurgical tests was conducted to explore the properties of the welded iron tubing. Both the recovery firing and the metallurgical tests indicated that the ingot-iron band blanks cut from welded tubing are essentially comparable with the blanks machined from bar stock.

FOREWORD

This investigation was authorized by reference (a) and was conducted under Task Assignment NPG-Re3b-225-1-53 (reference (b)). This is the final report on The Ballistic and Metallurgical Test of Welded Armco Tubes and is the eighth partial report on Projectile Rotating Bands and Related Components.

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INTRODUCTION

Tests conducted with Armco ingot iron as a rotating band material resulted in the development of band designs for both the 3"/50 and the 3"/70 projectiles which performed well in slow fire (the details of the 3"/70 band development were reported in reference (c)). The next step was to obtain a sufficient number of projectiles having bands of the two designs for rapid fire gun life tests.

The Armco iron bands used for the tests in which these designs were evolved were made by machining blanks from solid bars of Armco iron. This procedure was obviously not economical for the large number of blanks required for the rapid fire tests. Although copper and gilding metal band blanks are normally cut from seamless tubing, there has been no commercial demand for seamless ingot iron tubing, and no company is properly equipped to produce it. Furthermore, the hot working properties of ingot iron are such that there is considerable doubt in the metal industry that tubing can be produced by the seamless process. However, even if this is true, other commercial methods such as butt welding or hot extruding could undoubtedly be adapted to the production of an ingot iron tube.

To obtain a sufficient number of blanks for the first wear tests, other means of fabrication which would not involve considerable process development were sought. The Youngstown Welding and Engineering Company suggested that they could produce welded Armco ingot iron tubing from plate stock. A limited amount of this tubing was produced and was forwarded to the Naval Proving Ground for the evaluation covered by this report. Subsequent to this work another procedure for producing ingot iron band blanks was developed. This method, which involves forging a cup from a solid piece of Armco bar and slicing it into blanks, was the one adopted to produce the band blanks for the gun life tests. Tests of the material produced by this method are to be covered in a separate report.

DESCRIPTION OF MATERIAL

Band blanks made from welded Armco ingot iron tubing were received in two sizes, one nominally 3.700 I.D. x 3.770 O.D. for use on 3"/70 projectiles, the other nominally 3.700 I.D. x 3.740 O.D. for use on 3"/50 projectiles. For comparison, blanks of both sizes were machined from the same 6" Armco bar used for making the bands tested earlier.

Rotating bands were removed from eight standard 3"/50 A.A. Projectiles Mk 33 Mod 0 and eight 3"/70 A.A. Projectiles Type Ex 24 Mod 2. New band blanks were swaged on these projectiles, four made from welded iron tubing and four machined from bar stock. The swaged bands on the 3"/50 projectiles were machined to the contour shown in Figures 1 and 19. The swaged bands on the 3"/70 projectiles were machined to the contour shown in Figures 10 and 20. The bands of both the 3"/50 and the 3"/70 projectiles were coated before firing with molybdenum disulfide suspended in plastic paint.

DESCRIPTION OF TEST EQUIPMENT

A 3"/50 barrel Mk 21 Mod 0, No. 12593, was used in this test. This barrel has conventional rifling of 0.003 constant depth, and a uniform twist of 1/32. At the beginning of the test it had 2833 ESR and a 0.116 origin of bore enlargement.

A 3"/70 barrel Type G Mod 3, No. 24493, was also used in this test. This barrel has conventional rifling of 0.045 constant depth and a uniform twist of 1/25. At the beginning of the test it had 440-450 ESR and a 0.010 origin of bore enlargement.

PROCEDURE

Specimens of the 3"/50 and 3"/70 welded tubing were cut for metallurgical and physical testing. A complete hardness survey was performed on the weld zone, heat-affected zone and the unaffected base metal of the band blanks. Rockwell (F) hardness readings were taken on the periphery and on the ground surface of the experimental bands made from the tubing and from the bar stock. Drillings were obtained for chemical analysis. A bend test in accordance with reference (d) was performed on both the 3"/50 and 3"/70 welded band blanks.

For examination of the macrostructure, band blanks obtained from the welded tubing were surface ground, cleaned and etched in ammonium persulfate solution. Metallographic specimens of the weld and surrounding areas were prepared in the normal manner and etched with a nital solution. A metallographic specimen taken from the bar stock was prepared in a similar manner.

When it was determined by the metallurgical tests that both the 3"/70 and 3"/50 band blanks were cold worked, all blanks used for the ballistic test were normalized (heated to 1700°F, held 3 hours, air cooled) before being swaged on the projectiles.

The projectiles were loaded with Epsom salt to a total weight of 13 pounds for the 3"/50 projectiles and 15 pounds for the 3"/70 projectiles. All projectiles were fitted with flat nose plugs (see Figure 21), and were rubber crimped in the cases. Two rounds of each type were fired at service pressure and two at proof pressure in each gun. Velocities, copper crusher gauge pressures, spin measurements, case pressures, and barrel strain measurements were taken. Spin was measured by the wire impression method (see Appendix (E)). Projectile flight was checked by means of yaw cards at three positions. All rounds were recovered in sawdust. Measurements were taken of the cavity diameters and overall length before and after firing to determine the extent of deformation. Photographs of each round were taken after recovery and are shown in Figures 2 through 9 and Figures 11 through 18.

RESULTS AND DISCUSSION

After-recovery firing data are given in Tables 1 and 2 (Appendix (A)). All rounds fired showed good flight to the recovery bin with only slight yaw, good spin, no fringing, and uniform pressure and velocity. On the recovered projectiles (Figures 2 through 18), the engraving of the two band materials, fired in either gun at either service or proof pressure, was essentially identical. The cavity deformation under the band for the two materials was about the same.

Case pressures and barrel strain measurements were recorded on both the 3"/50 and 3"/70 test. The results are reported in Tables 3 and 4 (Appendix (C)). Photographs of the oscillograph records are included as Figures 22 through 26. The case pressures and barrel strain measurements taken on the 3"/50 and 3"/70 gun barrels revealed no great difference between the projectiles with bands machined from welded tubing and those machined from bar stock material.

Chemical analyses of the welded tubing and the bar stock gave the following results:

Material	C	Mn	S
3"/50 Welded Tubing	.030	.033	.023
3"/70 Welded Tubing	.028	.030	.020
Bar Stock	.025	.025	.029

These analyses are typical of commercial low carbon steel (ingot iron) made by the open-hearth process.

Examination of the metallographic specimens (Figures 27 and 28) of the welded tubing showed the weld fusion to be complete. In the weld zone, large stringers of iron oxide had been formed during the welding process; these might have caused a definite plane of weakness in the weld metal but the bend tests did not appear to have been markedly affected. Photographs of the samples before and after testing (Figure 34) indicated that slight cracking took place in the weld metal, but there was no evidence of failure. In the heat-affected zone, coarse ferrite grains were present as a

result of the welding heat. A normal polyhedral ferrite grain structure existed approximately one inch from the weld zone. The extent of these zones is illustrated by the macro-etched specimens (Figure 29). A hardness survey performed on the ground macro-etched specimens is shown in Figure 30. It was noted that the 3"/70 welded tubing had a lower average hardness than the 3"/50 welded tubing. The 3"/50 tubing apparently had been produced from the same plate stock as the 3"/70 tubing by cold rolling or forging and was therefore cold-worked to a greater degree, as is shown by the microstructures in Figure 31.

After the normalization of the two types of band blank, as described above, the hardness survey (Figure 33) and the microstructure (Figure 31) indicated that favorable results had been obtained.

The following table shows the average hardnesses observed for the band blanks, and for the swaged and machined bands made from each type of blank:

Rockwell F Hardness

	Band blank as received	Band blank normalised	Band
3"/70 Tubing	87	83	100
3"/50 Tubing	98	81	103
Bar Stock	76	--	83

The low hardness of the bar stock, and its large grain size (Figure 32), indicate that the bar had been thoroughly annealed.

The difference in the hardness of the blanks before banding and the difference in the response of the material to cold work during the swaging operation resulted in the 12-15 R_F hardness difference in the bands. It is considered that a hardness difference of this magnitude would not affect performance in the recovery firing appreciably. However, since a few points of hardness might have an effect on gun erosion, annealing would be advisable if numbers of welded band blanks are to be produced for a gun wear test.

Since all the firing results appeared to be normal, and there was no evidence of incipient weld failure in the recovered bands, the fabrication of band blanks from welded ingot-iron tubing appears entirely satisfactory.

CONCLUSIONS

Both the recovery firing and the metallurgical tests indicated that the Armco iron band blanks cut from welded tubing are essentially comparable with those machined from ingot iron bar stock. If this method is ever used for the production of ingot-iron band blanks, it would be advisable to subject them to a softening treatment before they are put on the projectiles.

REFERENCES

(a) BUORD Conf ltr NP9 Re3b-MRH:mt Ser 42696 of 29 July 1952
(b) BUORD Conf ltr NOrd 12376 Re3b-MAS:MRH:mel Ser 43007 of 1 August 1952
(c) NPG Conf Report No. 896 of 29 November 1951
(d) Rotating Band Specification O.S. 1366

APPENDIX A

TABLE 1

FIRING DATA

Test of 3"/50 Projectiles with Iron Bands Fired in Gun No. 12593 Mk 21 Mod 0

Proj. No.	Firing Order 10/8/52	Powder Charge (lbs.)	Average Pressure (T/in.^{2})	Muzzle Velocity (ft./sec.)	Nominal Spin ∱	Band Type	Hardness Rockwell "F"	Deformation (in.)
1818	1	4.70	17.3	2919	99.47	Bar Stock	85-90	-.001
1819	2	4.70	17.8	2915	99.97	Bar Stock	88-91	.000
1822	3	4.70	17.5	2915	99.97	Tubing	102-104	-.001
1823	4	4.70	16.6	2917	99.38	Tubing	102-104	-.001
1816	5	4.20	13.3	2703	98.99	Bar Stock	89-92	-.001
1817	6	4.20	13.8	2696	98.69	Bar Stock	88-90	-.002
1820	7	4.20	13.9	2670	99.38	Tubing	103-105	-.001
1821	8	4.20	13.6	2687	98.59	Tubing	98-101	-.001

Test of 3"/50 Projectiles with Iron Bands fired in Gun No. 12593 Mk 21 Mod 0 1/32 Twist. ESR 2850.
All rotating bands were coated with molybdenum disulfide and plastic paint before firing.

TABLE 2

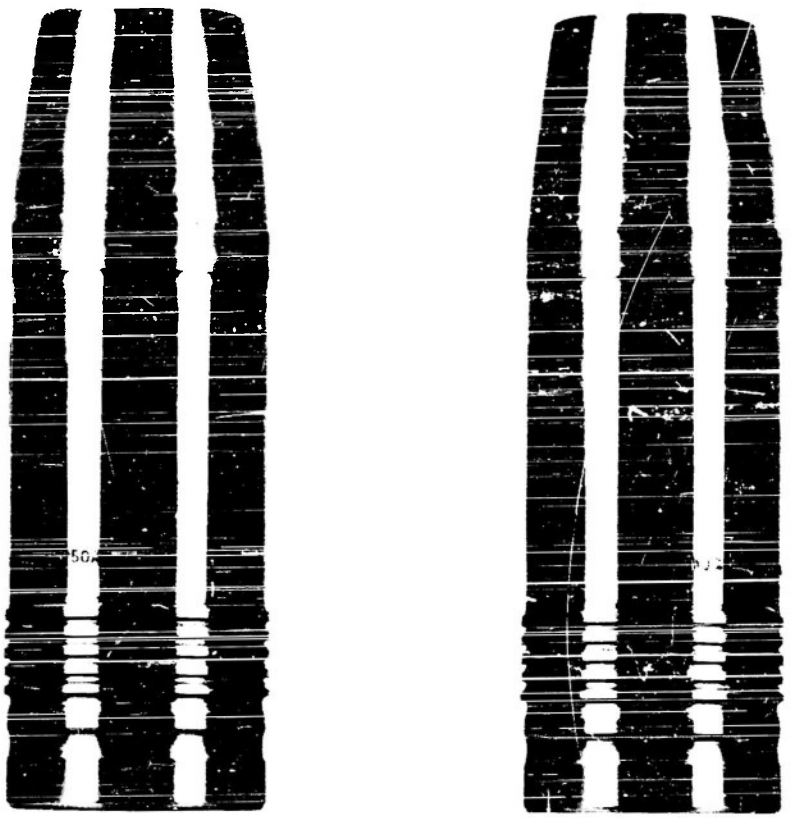
FIRING DATA

Test of 3"/70 Mk 24-2 with Iron Bands in Gun Type G Mod 3 No. 24493

Proj. No.	Firing Order 10/10/52	Powder Charge (lbs.)	Average Pressure (T/sq.in.)	Muzzle Velocity (ft./sec.)	Nominal Spin %	Band Type	Hardness Rockwell "F"	Deformation (in.)
1829	1	10.50	24.3	3627	99.58	Bar Stock	85-87	-.012
1830	2	10.50	21.6	3604	99.49	Bar Stock	88-89	-.008
1833	3	10.50	21.2	3590	99.09	Tubing	99-102	-.015
1834	4	10.50	22.8	3664	99.09	Tubing	100-102	-.008
1837	5	9.86	20.5	3419	100.08	Bar Stock	84-87	-.011
1838	6	9.86	19.2		98.53	Bar Stock	83-86	-.009
1831	7	9.86	19.4	3408	99.83	Tubing	99-100	-.008
1832	8	9.86	19.9	3459	98.39	Tubing	99-101	-.013

Gun Type G Mod 3 No. 24493 had 440 ESR prior to test.
All rounds crimped in case.
All rotating bands were coated with molybdenum disulfide and plastic paint before firing.

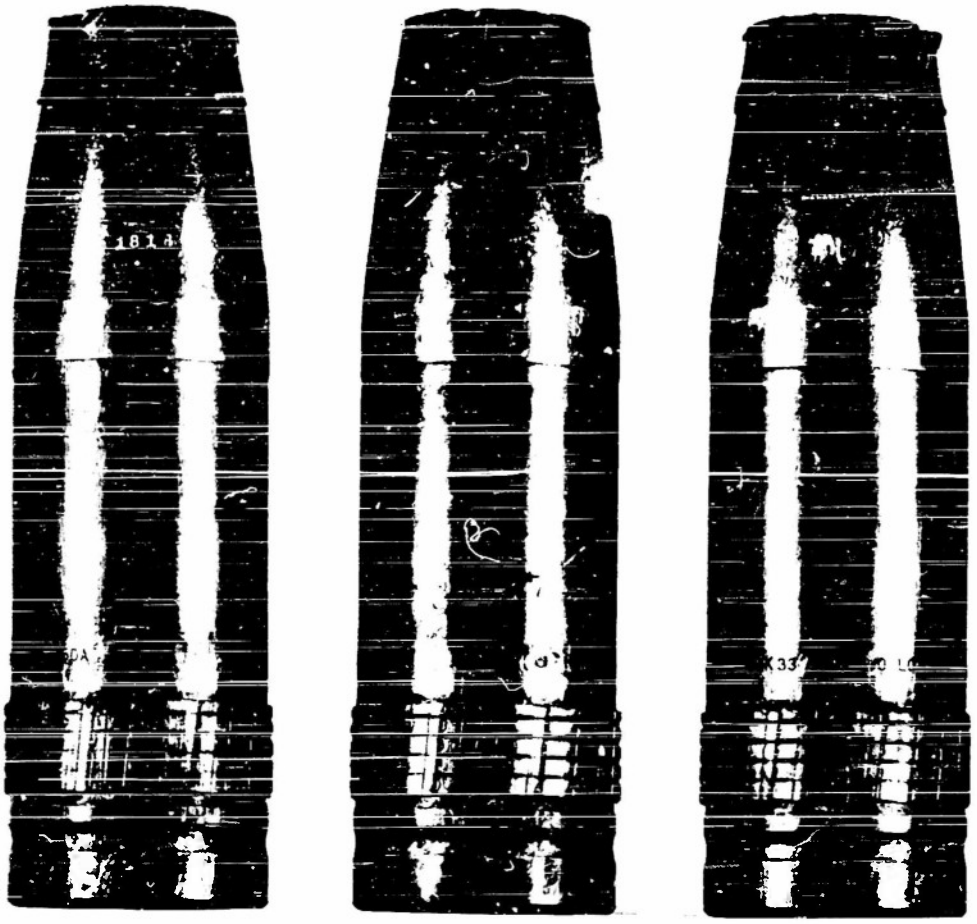
APPENDIX B



NP9-51963 22 January 1953 CONFIDENTIAL

Photograph of 3"/50 AA Mk 33 Mod 0 Projectiles, with iron band machined from bar stock (left) and iron band machined from welded tubing (right), before firing.

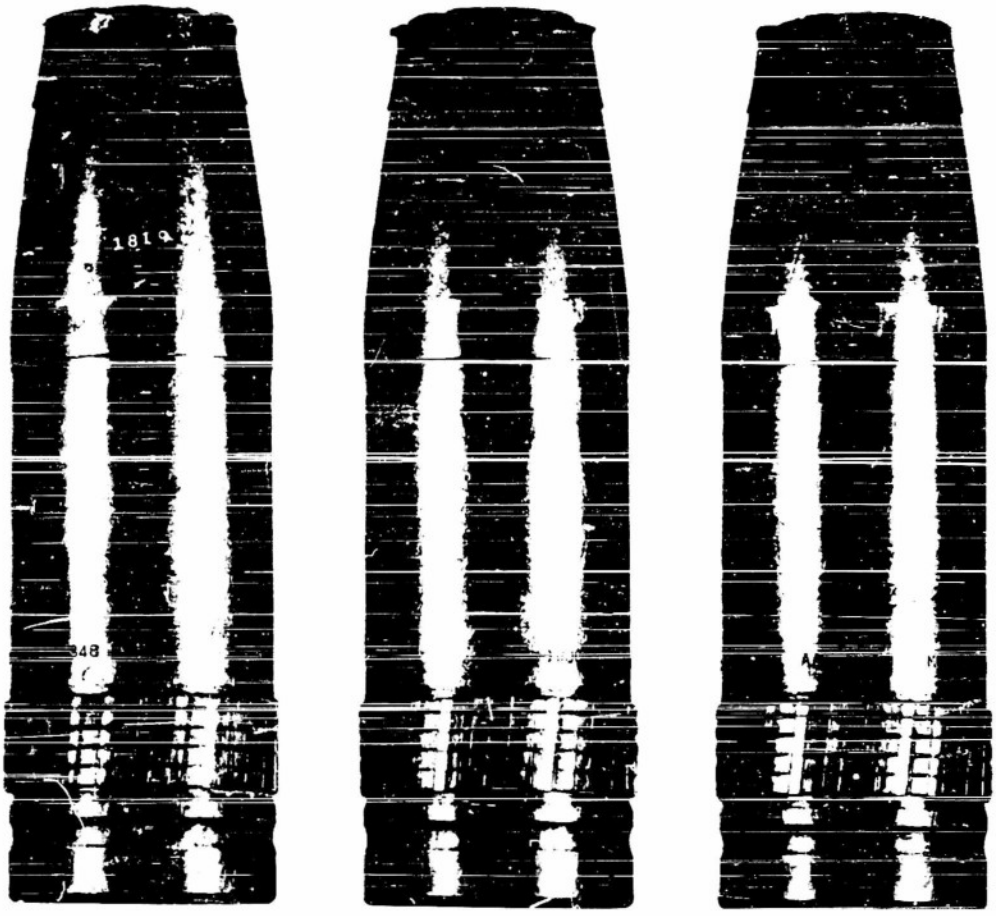
Figure 1



NP9-51964 22 January 1953 CONFIDENTIAL

Three views (120° apart) of recovered 3"/50 AA Mk 33 Mod 0 Projectile, with iron band machined from bar stock. Projectile No. 1818.

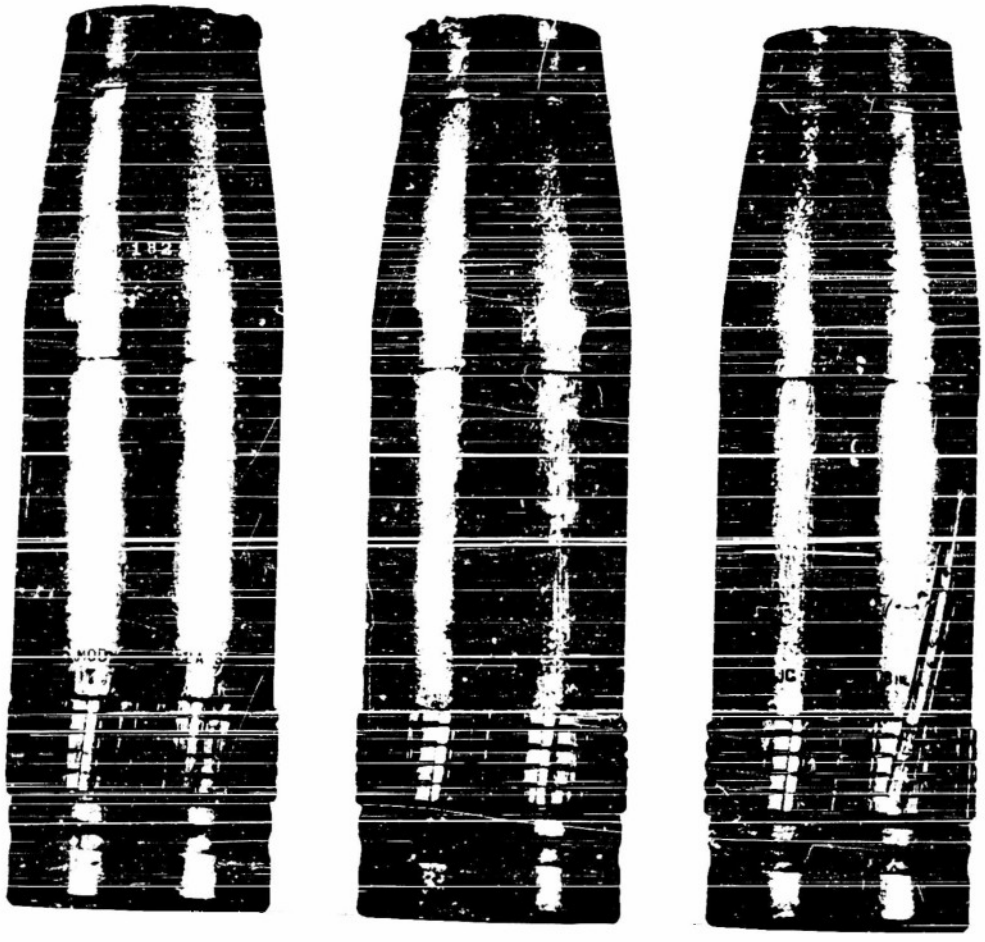
Figure 2



NP9-51965 22 January 1953 CONFIDENTIAL

Three views (120° apart) of recovered 3"/50 AA Mk 33 Mod 0 Projectile, with iron band machined from bar stock. Projectile No. 1819.

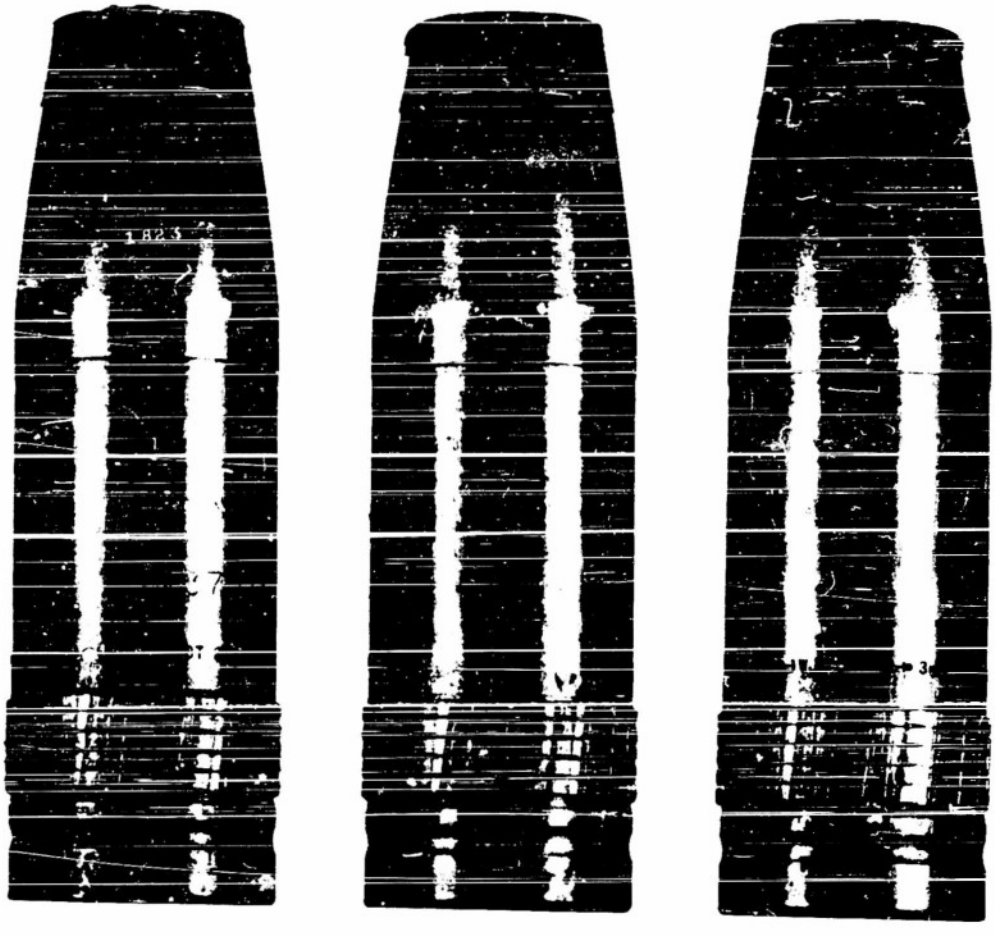
Figure 3



NP9-51966 22 January 1953 CONFIDENTIAL

Three views (120° apart) of recovered 3"/50 AA Mk 33 Mod 0 Projectile, with iron band machined from welded tubing. Projectile No. 1822.

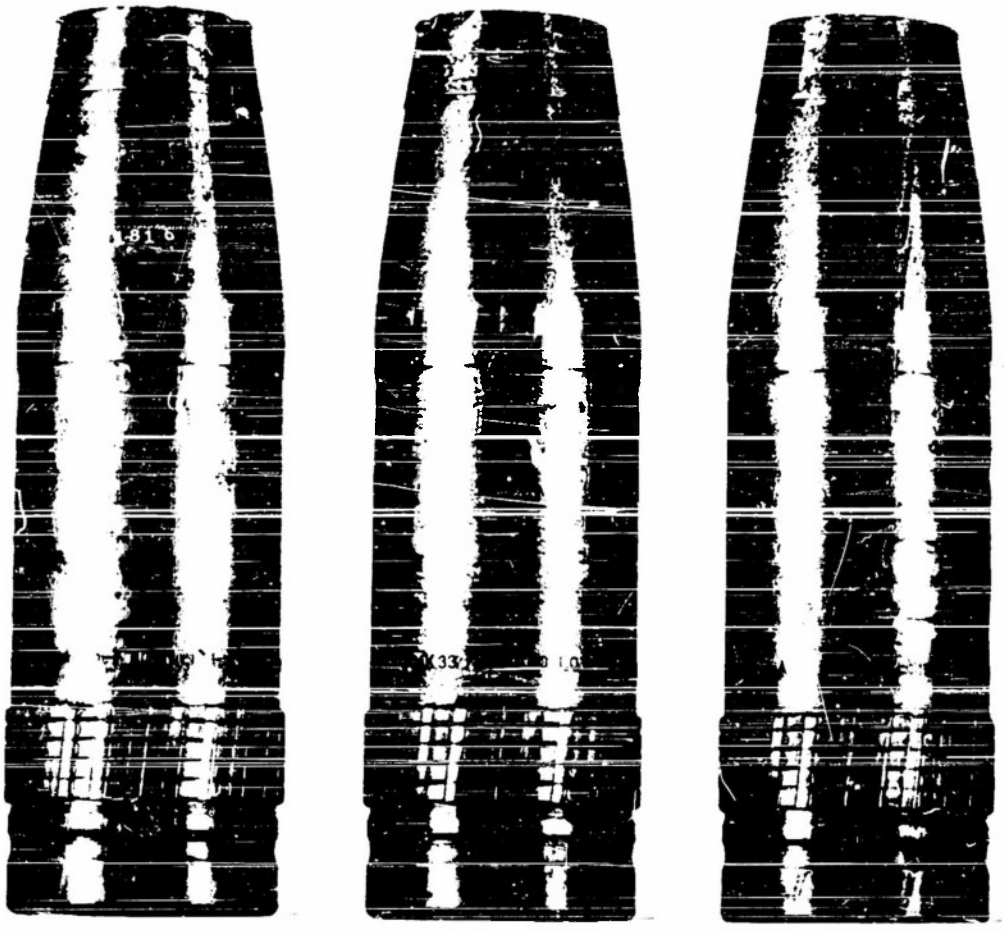
Figure 4



NP9-51967 22 January 1953 CONFIDENTIAL

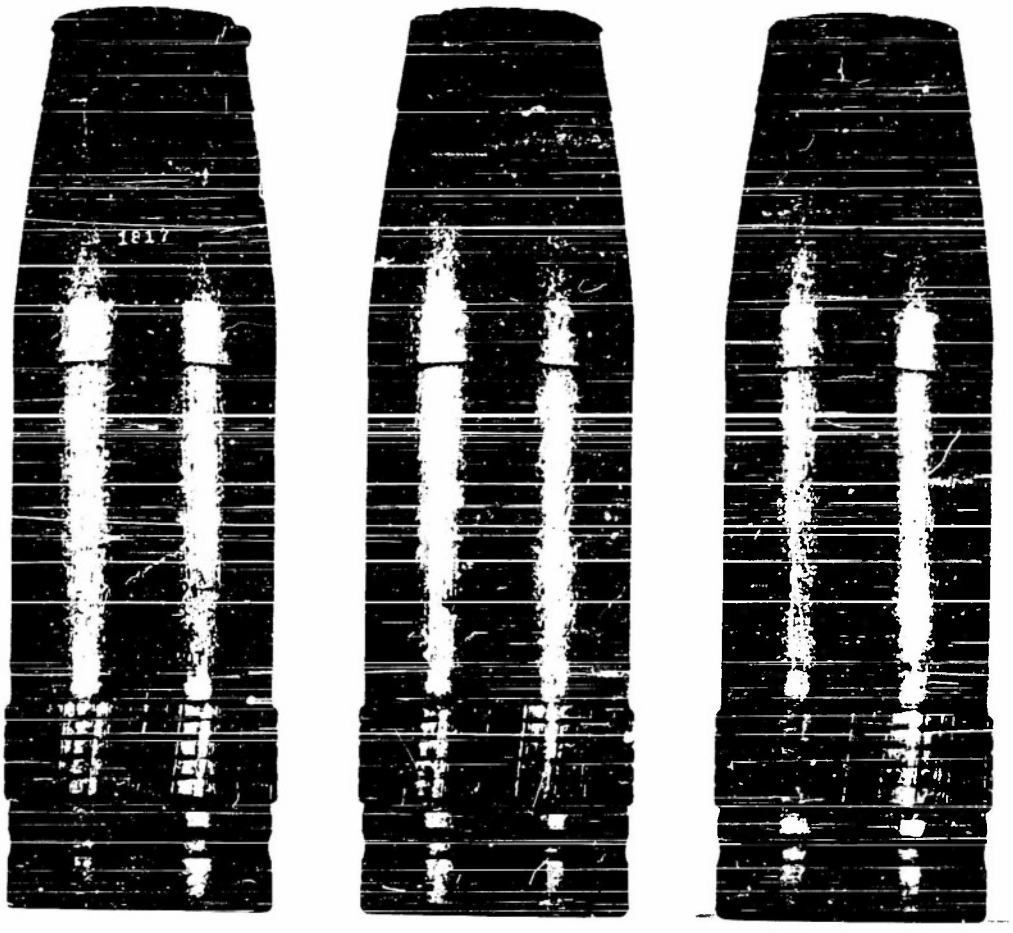
Three views (120° apart) of recovered 3"/50 AA Mk 33 Mod 0 Projectile, with iron band machined from welded tubing. Projectile No. 1823.

Figure 5



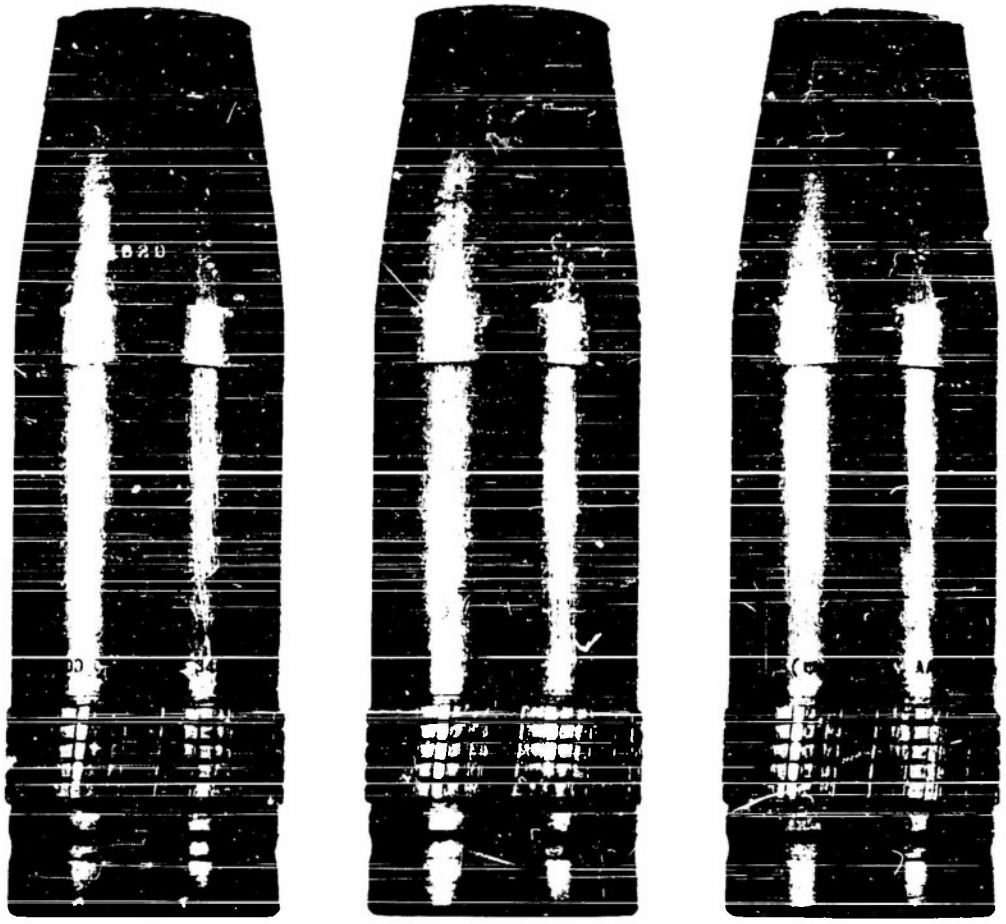
Three views (120° apart) of recovered 3"/50 AA Mk 33 Mod 0 Projectile, with iron band machined from bar stock. Projectile No. 1816.

Figure 6



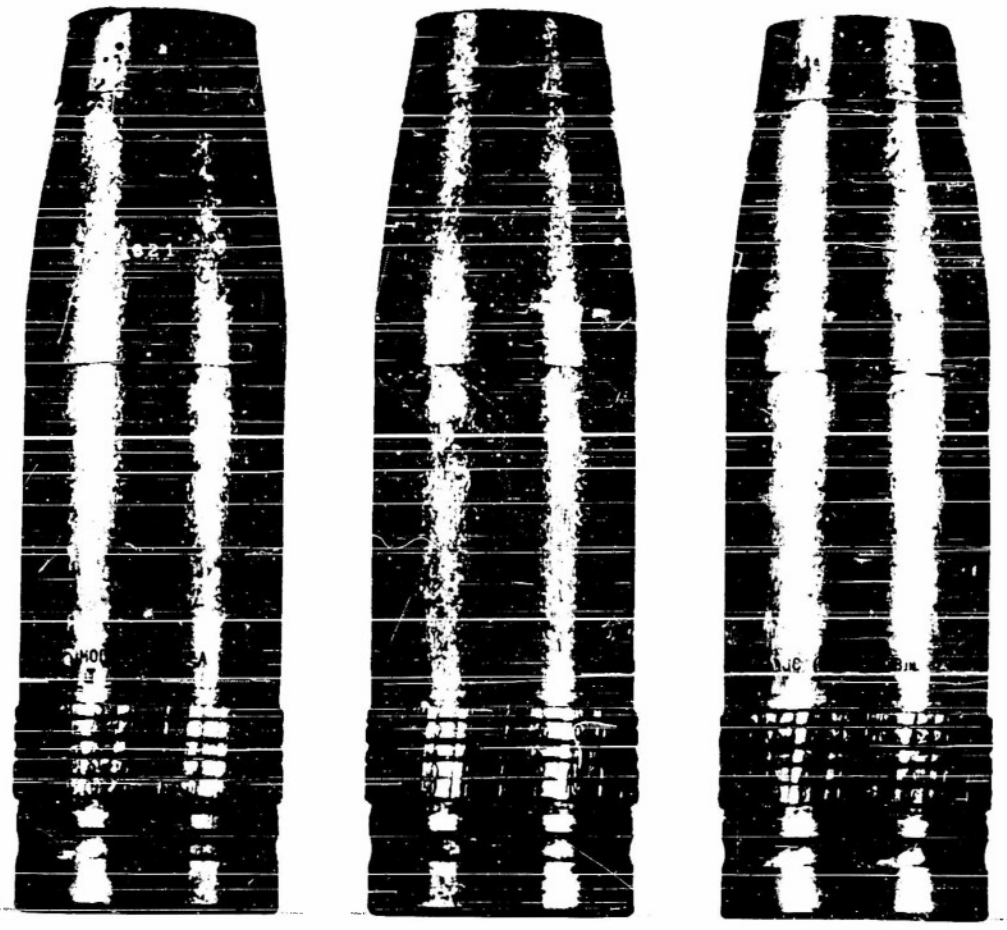
Three views (120° apart) of recovered 3"/50 AA Mk 33 Mod 0 Projectile, with iron band machined from bar stock. Projectile No. 1817.

Figure 7



Three views (120° apart) of recovered 3"/50 AA Mk 33 Mod 0 Projectile, with iron band machined from welded tubing. Projectile No. 1820.

Figure 8



NP9-51971 22 January 1953 CONFIDENTIAL

Three views (120° apart) of recovered 3"/50 AA Mk 33 Mod 0 Projectile, with iron band machined from welded tubing. Projectile No. 1821.

Figure 9

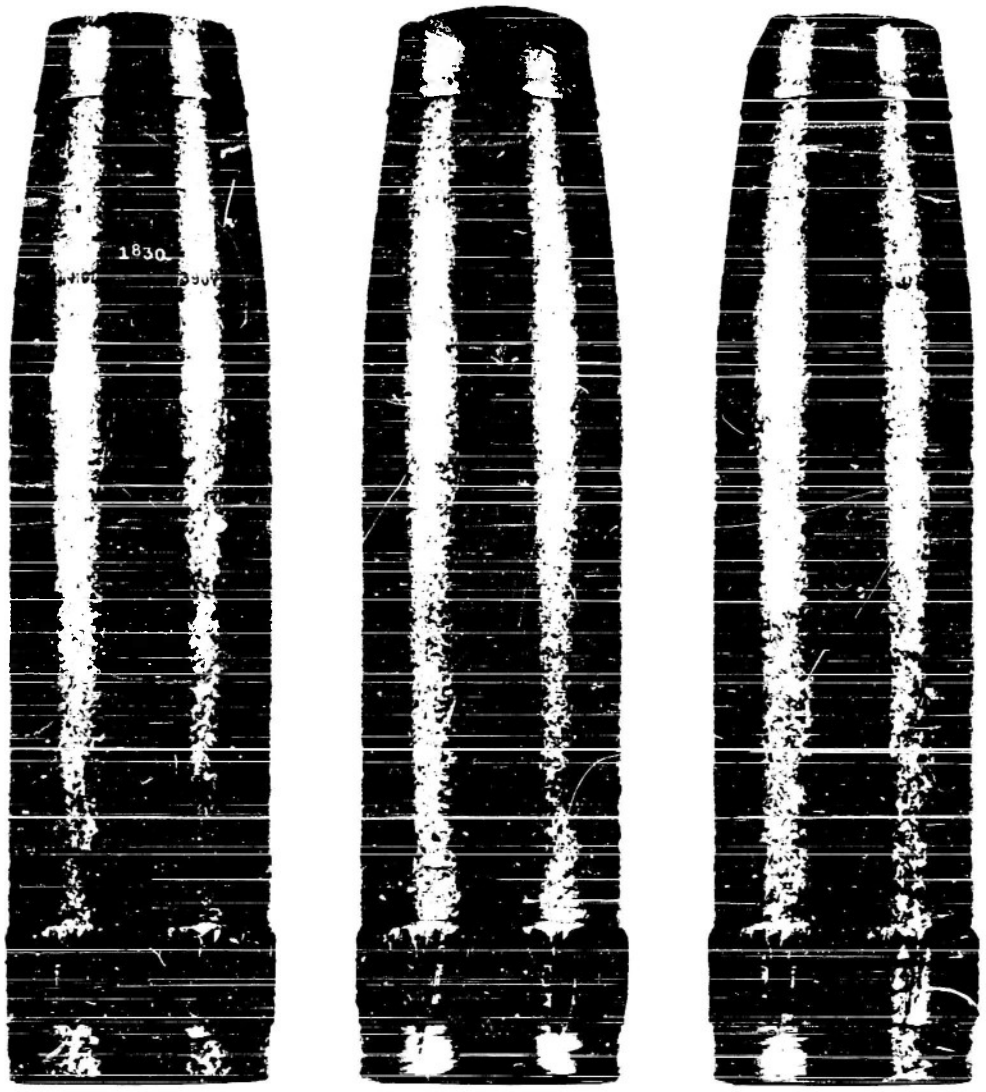
Photograph of 3"/70 EX 24 Mod 2 Projectiles, with iron band machined from bar stock (left) and iron band machined from welded tubing (right), before firing.

Figure 10

NP9-51973 22 January 1953 CONFIDENTIAL

Three views (120° apart) of recovered 5"/70 EX 24 Mod 2 Projectile, with iron band machined from bar stock. Projectile No. 1829.

Figure 11



Three views (120° apart) of recovered 3"/70 EX 24 Mod 2 Projectile, with iron band machined from bar stock. Projectile No. 1830.

Figure 12

Three views (120° apart) of recovered 3"/70 EX 24 Mod 2 Projectile, with iron band machined from welded tubing. Projectile No. 1833.

Figure 13

NP9-51976 22 January 1953 CONFIDENTIAL

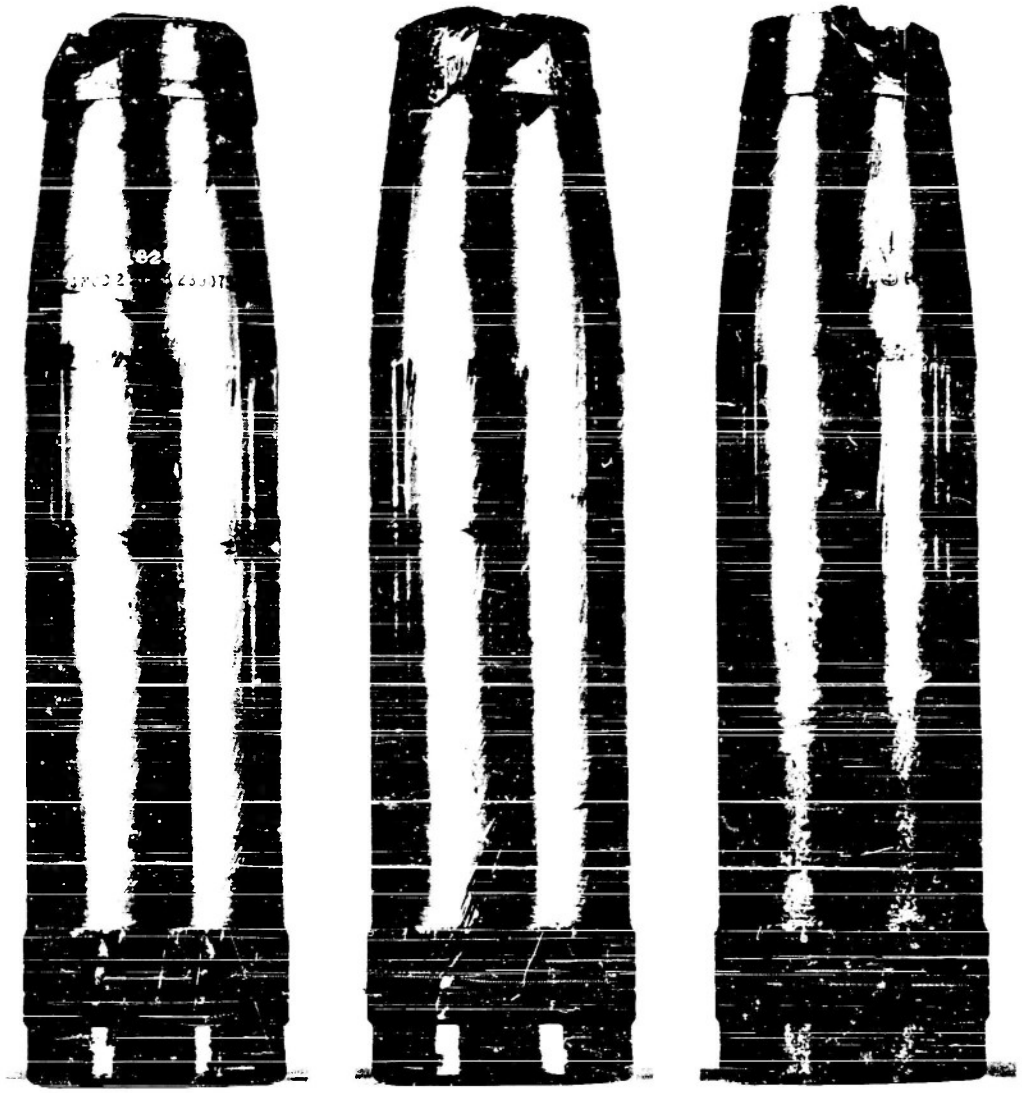
Three views (120° apart) of recovered 3"/70 EX 24 Mod 2 Projectile, with iron band machined from welded tubing. Projectile No. 1834.

Figure 14

NP9-51977 22 January 1953 CONFIDENTIAL

Three views (120° apart) of recovered 3"/70 EX 24 Mod 2 Projectile, with iron band machined from bar stock. Projectile No. 1827.

Figure 15



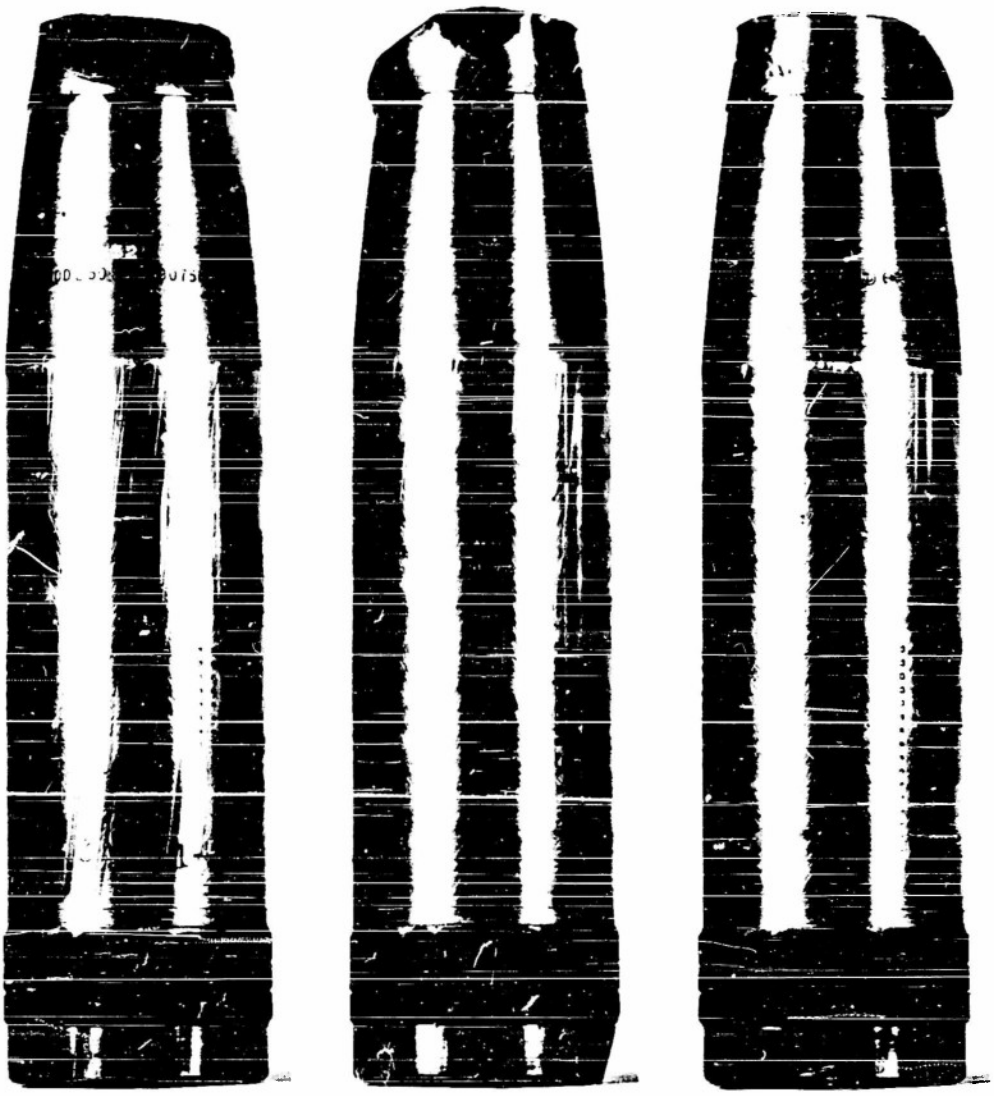
Three views (120° apart) of recovered 3"/70 EX 24 Mod 2 Projectile, with iron band machined from bar stock. Projectile No. 1828.

Figure 16

NP9-51979 22 January 1953 CONFIDENTIAL

Three views (120° apart) of recovered 3"/70 EX 24 Mod 2 Projectile, with iron band machined from welded tubing. Projectile No. 1831.

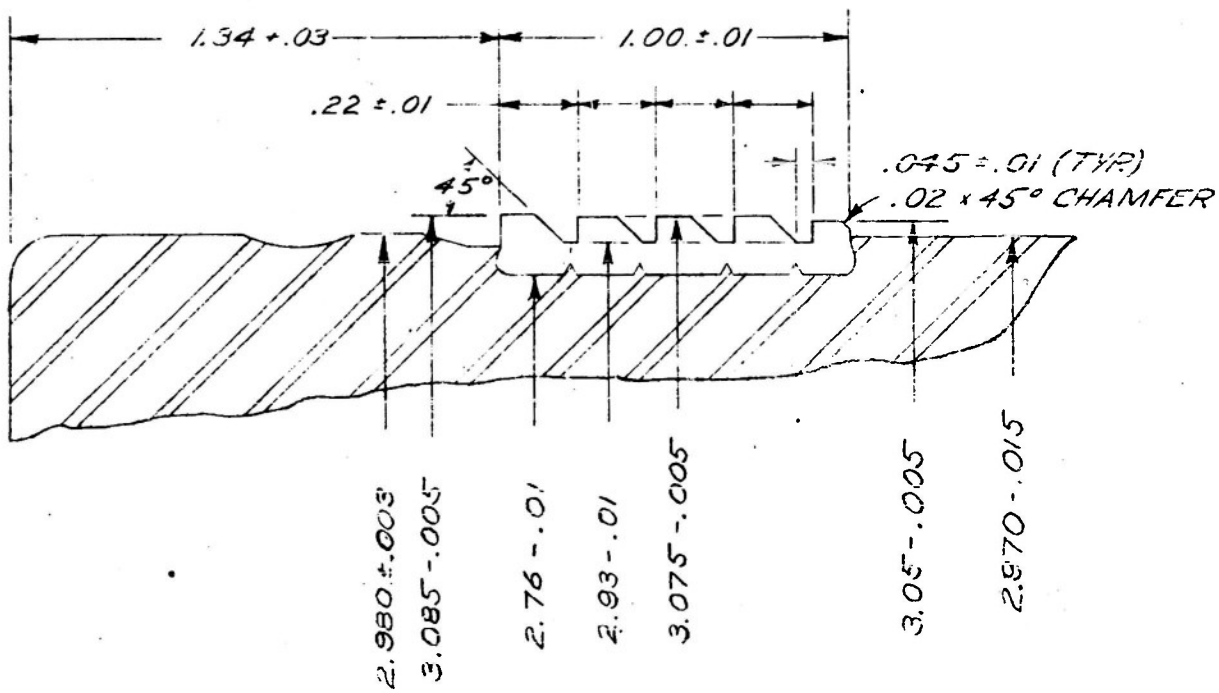
Figure 17



Three views (120° apart) of recovered 3"/70 EX 24 Mod 2 Projectile, with iron band machined from welded tubing. Projectile No. 1832.

Figure 18

REF. BuOrd DWG - 563840



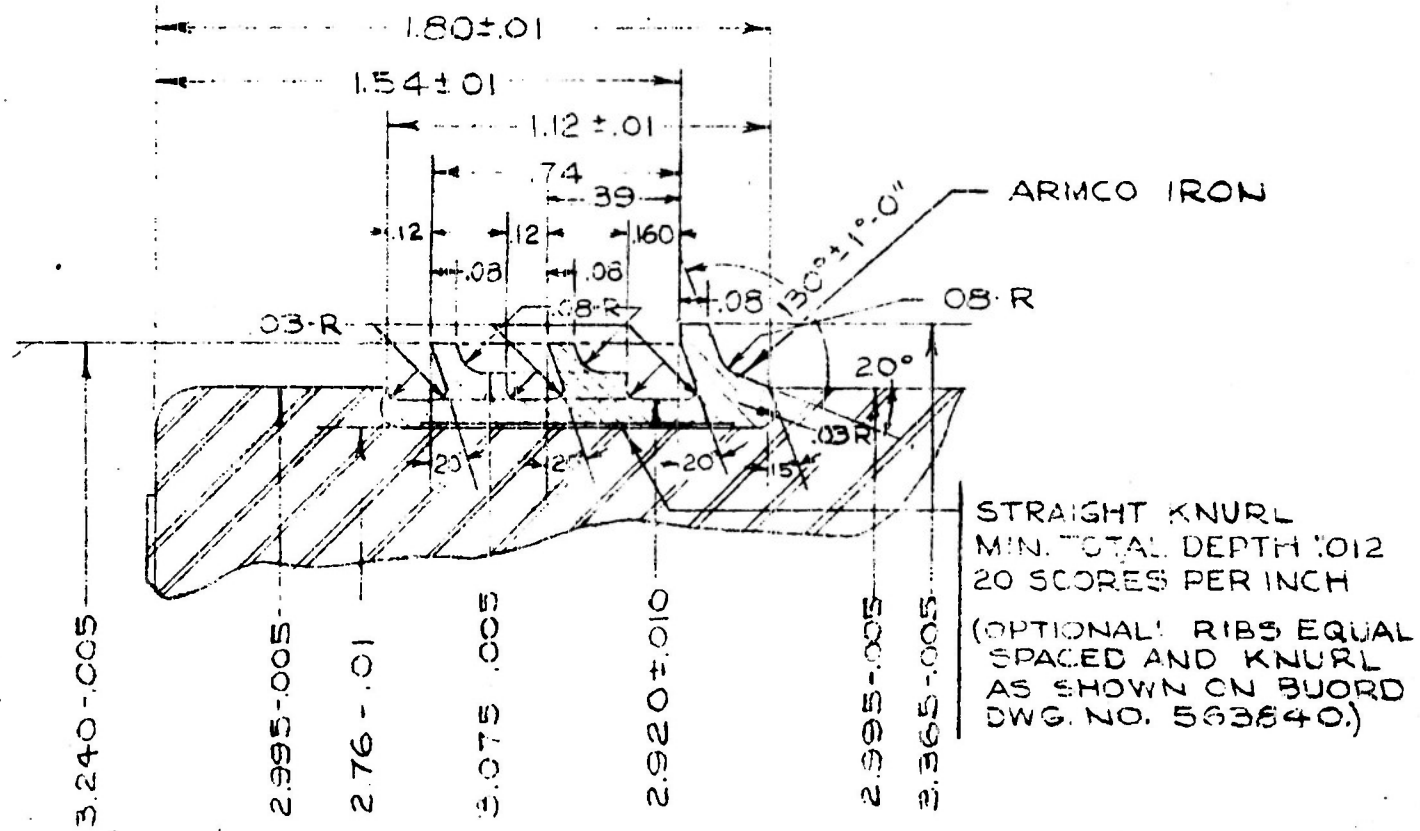
IRON BAND FOR 3"/50 PROJECTILE MK 33 MOD 0

DWG. NO.
APL - 564

6-23-54 GSM

FIGURE 19

FIGURE 20



3"/70 AA PROJECTILE TYPE EX 24 MOD 2. MODIFIED

SCALE - 2:1

REF: SEE BUORD DWG. NO. 239075

6/21/54

APL-

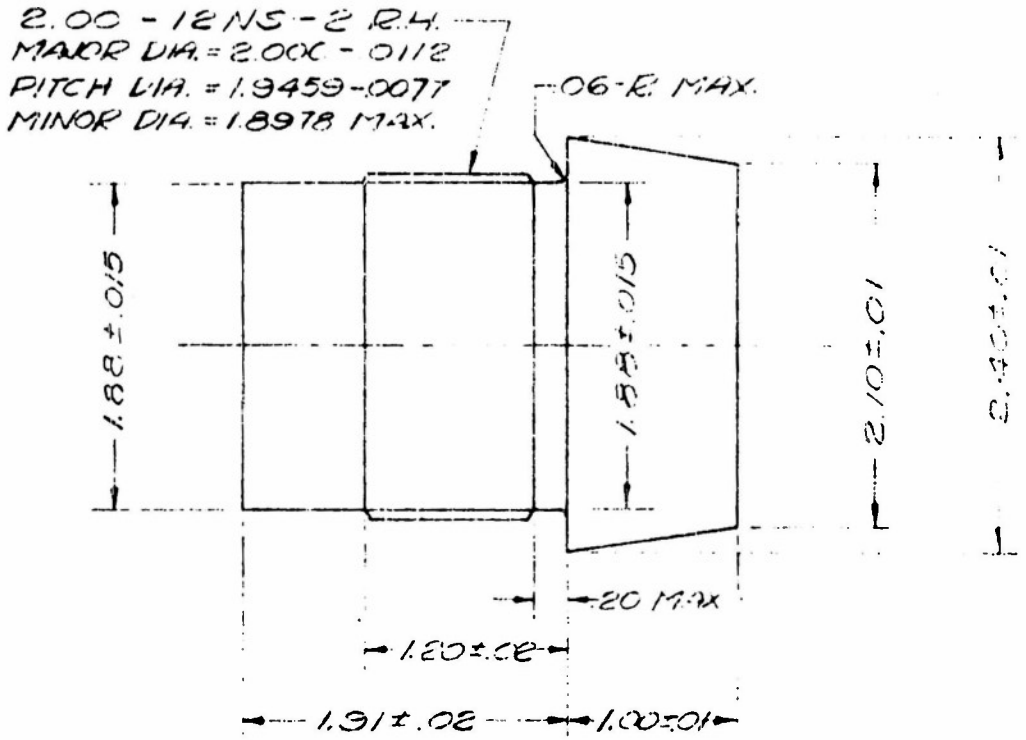


FIGURE 21

DUMMY NOSE PLUG

MATERIAL: STEEL, FORGED OR ROLLED STOCK.
WEIGHT: 2.68 ± .05 LBS.
NOTE: BREAK SHARP EDGES
REF: SEE BUORD SK. NO. 239269

APL-107
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APPENDIX C

TABLE 3

CASE PRESSURES AND BARREL STRAIN MEASUREMENTS

3"/50 Gun No. 12593

8 October 1952

Mk 33-0 Projectiles w/Armco Iron Bands

Proj. No.	Rd. No.	Copper Press. T/in.^{2}	Case Pressure (p.s.i.)	Barrel Strains in μ ins./in. Strain gauges located at the following positions from muzzle: 72"	36"	5"
1818	1	17.3	48,550	348	344	--
1819	2	17.8	50,000	366	366	--
1822	3	17.5	49,300	354	372	--
1823	4	16.6	46,700	348	364	--
1816	5	13.3	37,875	333	325	--
1817	6	13.8	34,175	340	319	--
1820	7	13.9	36,500	339	297	--
1821	8	13.6	37,900	328	320	--

Note: (1) 5" trace on record was not readable, owing to interference.

TABLE 4

CASE PRESSURE AND BARREL STRAIN MEASUREMENTS

3"/70 Type G Mod 3 Gun No. 24493

30 October 1952

Ex 24-2 Projectiles w/Armco Iron Bands

Proj. No.	Rd. No.	Copper Press. T/in.^{2}	Case Pressure (p.s.i.)	Barrel Strains in μins./in. Strain gauges located at the following positions from muzzle: 112"0	64"0	10"0
1829	1	24.3	64,200	451	468	756
1830	2	21.6	64,950	463	472	762
1833	3	22.2	64,600	466	463	758
1834	4	22.8	61,300	457	462	730
1827	5	20.5	54,900	447	460	729
1828	6	19.2	54,500	435	459	728 - 686
1831	7	19.4	54,800	441	453	735
1832	8	19.9	54,100	434	448	720

Note: (1) For Round 6, at 10"0 position two readings are given.

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3"/50 GUN NO. 12593

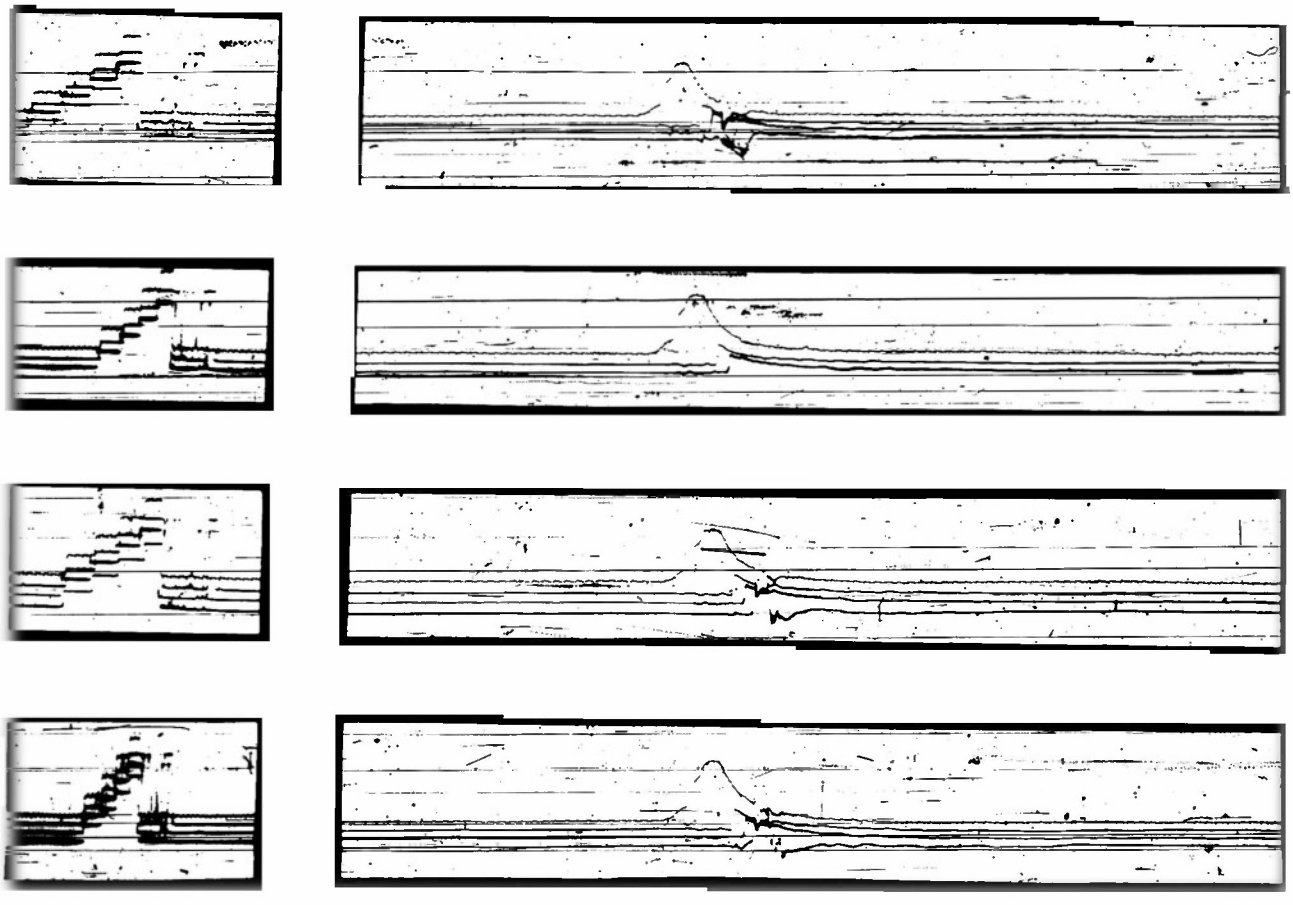
CASE PRESSURES & BARREL STRAIN MEASUREMENTS

TIMING MARKS - 1000 CPS; MAXIMUM ~~CALIBRATION~~ STEP 1.0 OHM
~~READING FROM TOP TO BOTTOM.~~

ROUNDS 1, 2, 3, & 4.

Gage Resistance - 500 Ohms
Gage Factor - 3.46

U. S. NAVAL ~~PROVING GROUND~~ Figure 22 8 OCTOBER 1952



NP9-51705

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3"/50 GUN NO. 12593

CASE PRESSURES & BARREL STRAIN MEASUREMENTS

TIMING MARKS - 1000 CPS; MAXIMUM CALIBRATION STEP 1.0 OHM
READING FROM TOP TO BOTTOM:

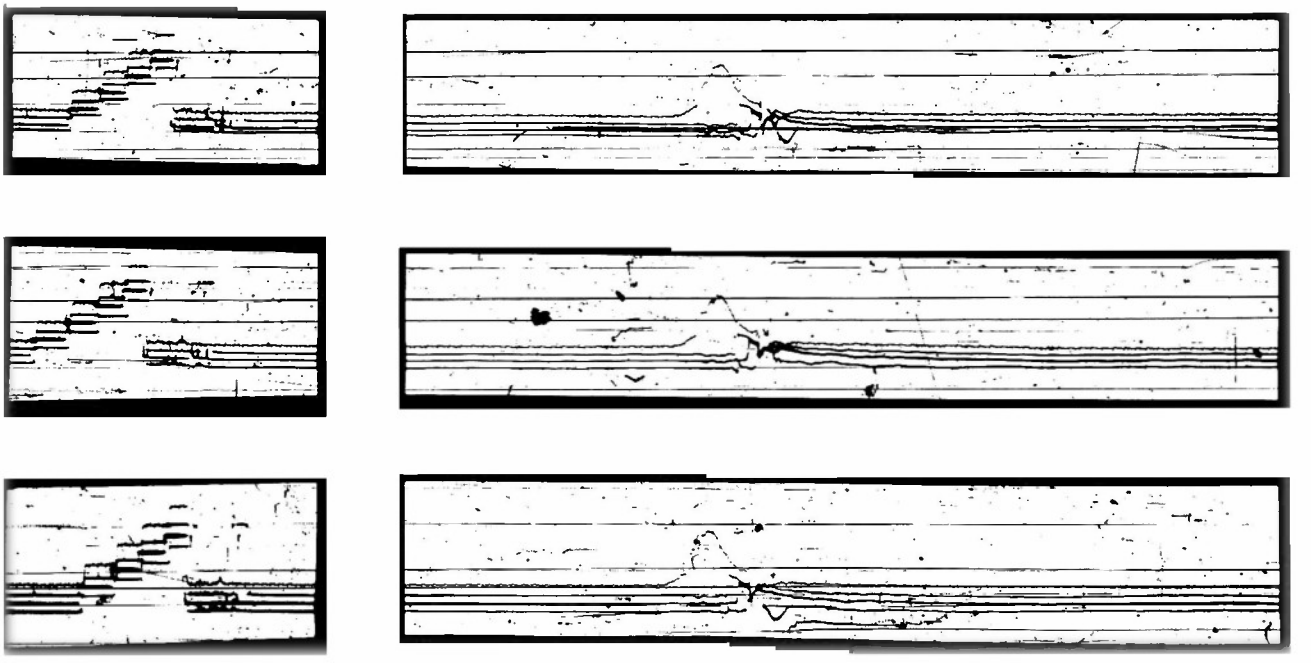
ROUNDS 5, 6, & 7.

Gage Resistance - 500 Ohms
Gage Factor - 3.46

U. S. NAVAL PROVING GROUND

8 OCTOBER 1952

Figure 23



NP9-51706 CONFIDENTIAL

3"/50 GUN NO. 12593

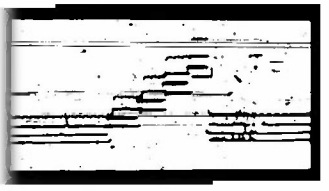
CASE PRESSURES & BARREL STRAIN MEASUREMENTS

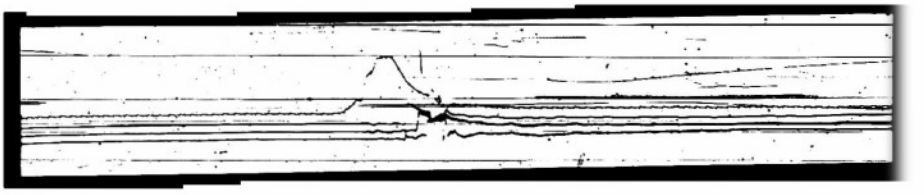
TIMING MARKS - 1000 CPS; MAXIMUM CALIBRATION STEP 1.0 OHM
READING FROM TOP TO BOTTOM:

ROUND 8

U. S. NAVAL PROVING GROUND 8 OCTOBER 1952

Figure 24





NP9-51707 CONFIDENTIAL

STRAIN RECORDS ON 3"/70 GUN TYPE C-3 NO.24493

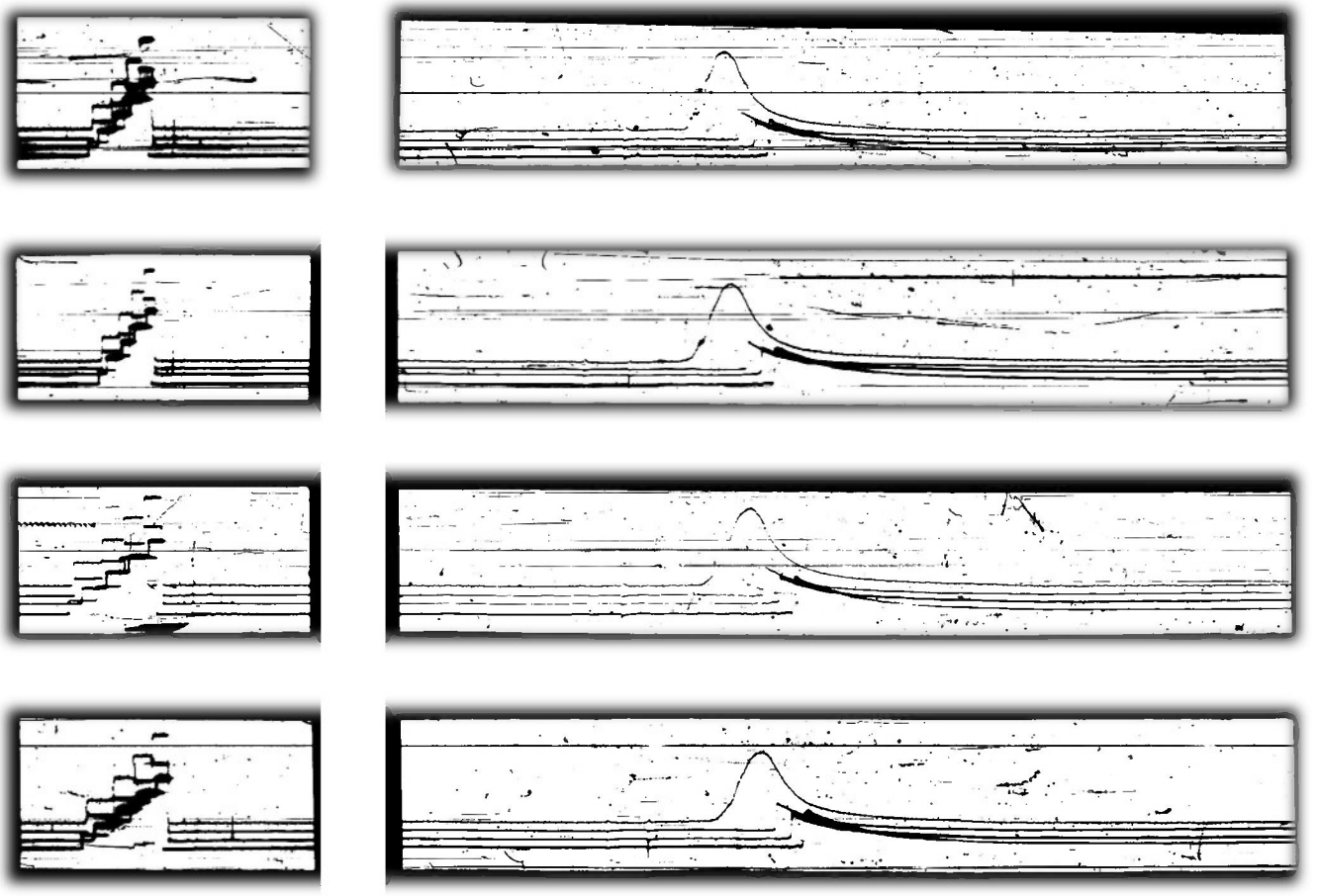
U. S. NAVAL PROVING GROUND 30 OCTOBER 1952

RECORD NO. (FROM TOP)	RD. NO.	PROJECTILE/BAND	PEAK STRAIN, μINS/IN. TRACE 2	TRACE 3	TRACE 4
1	1	EX24-2(ARMCO Fe STOCK BAND)	451	468	756
2	2	" " " "	463	472	762
3	3	" (ARMCO Fe TUBING BAND)	466	463	758
4	4	" " " "	457	462	730

NOTES: PEAKS 1, 2, 3 & 4 (L TO R) SHOW CASE PRESSURE & STRAINS 112", 64"& 10" FROM MUZZLE, RESPECTIVELY.

TIMING MARKS - 1000 CPS.

Figure 25



NP9-51708 CONFIDENTIAL

STRAIN RECORDS—CN 3"/70 GUN TYPE C-3 NO.24493

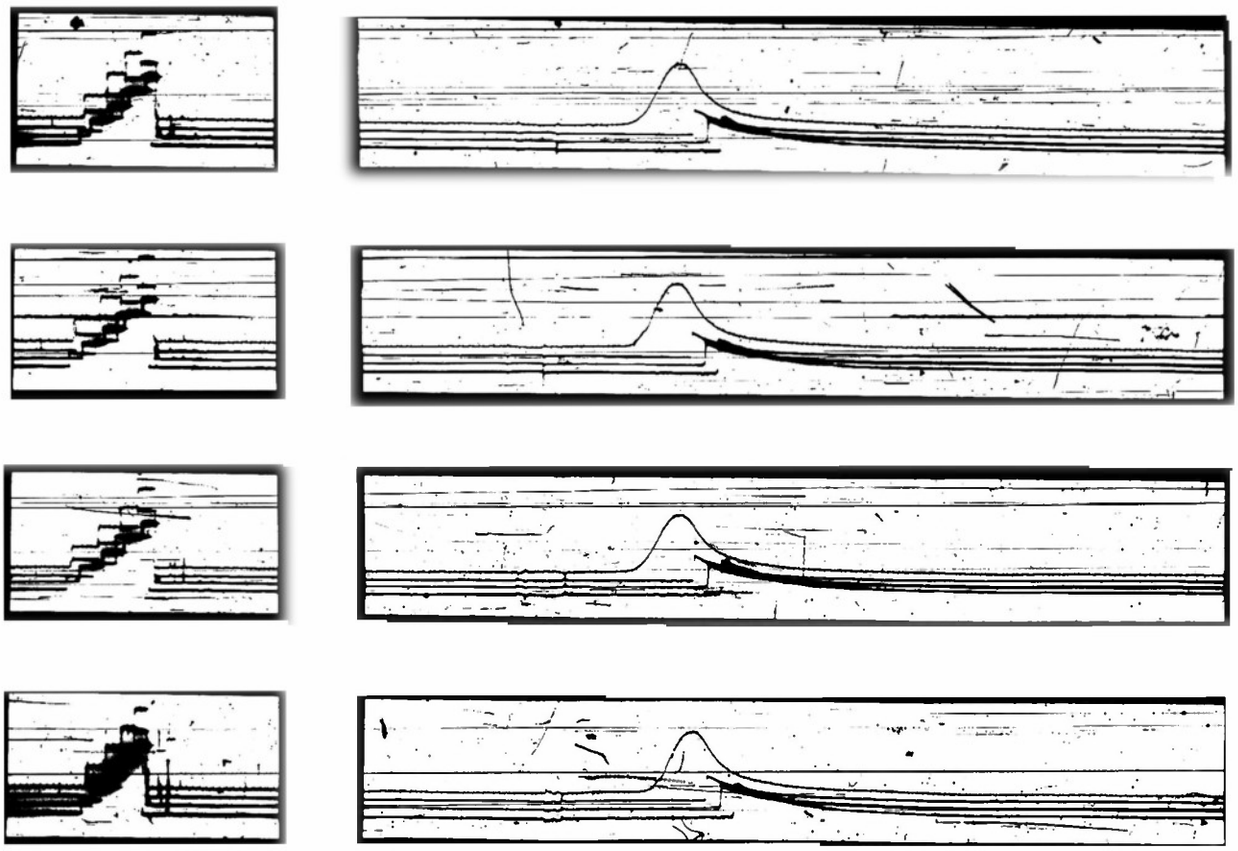
U. S. NAVAL PROVING GROUND 30 OCTOBER 1952

RECORD NO. (FROM TOP)	RD. NO.	PROJECTILE/BAND	PEAK STRAIN, μ INS/IN. TRACE 2	TRACE 3	TRACE 4
1	5	EX24-2(ARMCO Fe STOCK BAND)	447	460	729
2	6	" " " "	435	459	728
3	7	" (ARMCO Fe TUBING BAND)	441	453	735
4	8	" " " "	434	448	720

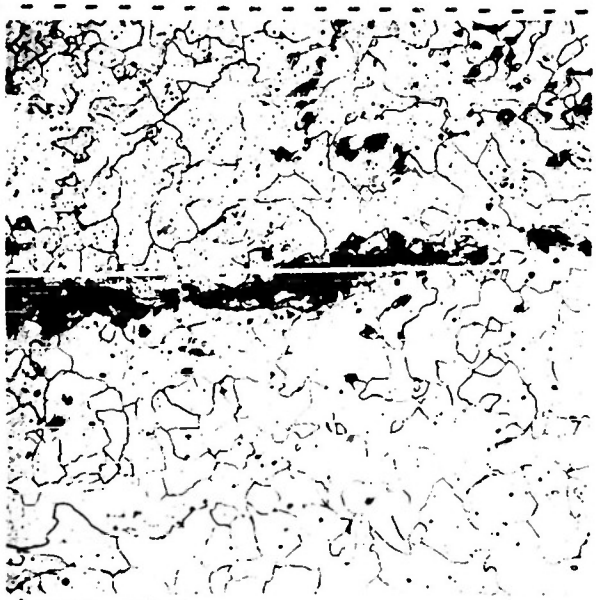
NOTES: PEAKS 1, 2, 3 & 4 (L TO R) SHOW CASE PRESSURE & STRAINS 112", 64" & 10" FROM MUZZLE, RESPECTIVELY.

TIMING MARKS - 1000 CPS.

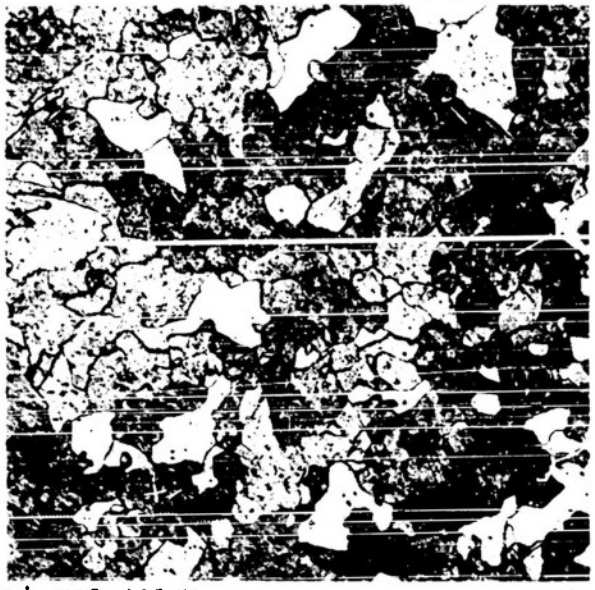
Figure 26



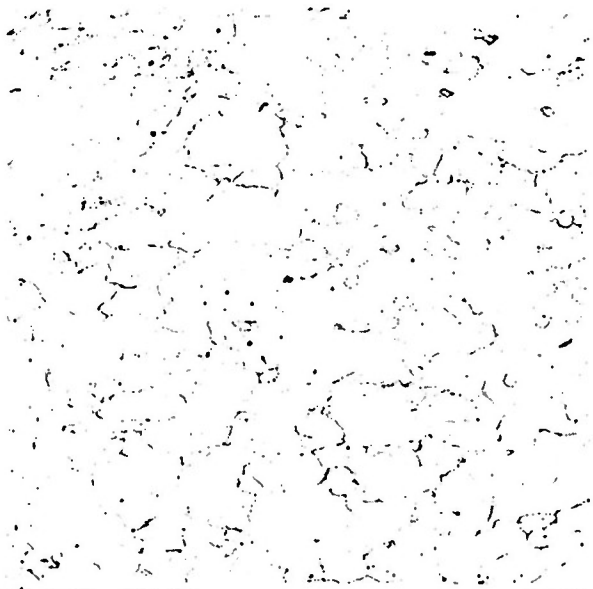
APPENDIX D



(A) NP9-49153 100X
Weld metal - note the stringers of iron oxide inclusions.
ASTM Grain Size No. 4 Nital Etch



(B) NP9-49154 100X
Coarse ferrite grains in the heat-affected zone.
ASTM Grain Size No. 3 Nital Etch

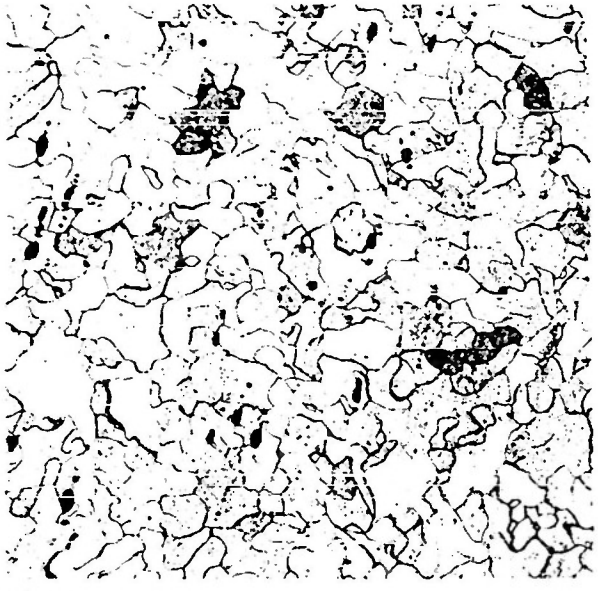


(C) NP9-49155 100X
Normal ferrite polyhedral grains in the non-heat-affected base metal.
ASTM Grain Size No. 5 Nital Etch

Microstructures in the 3"/50 Welded Tube Rotating Band.

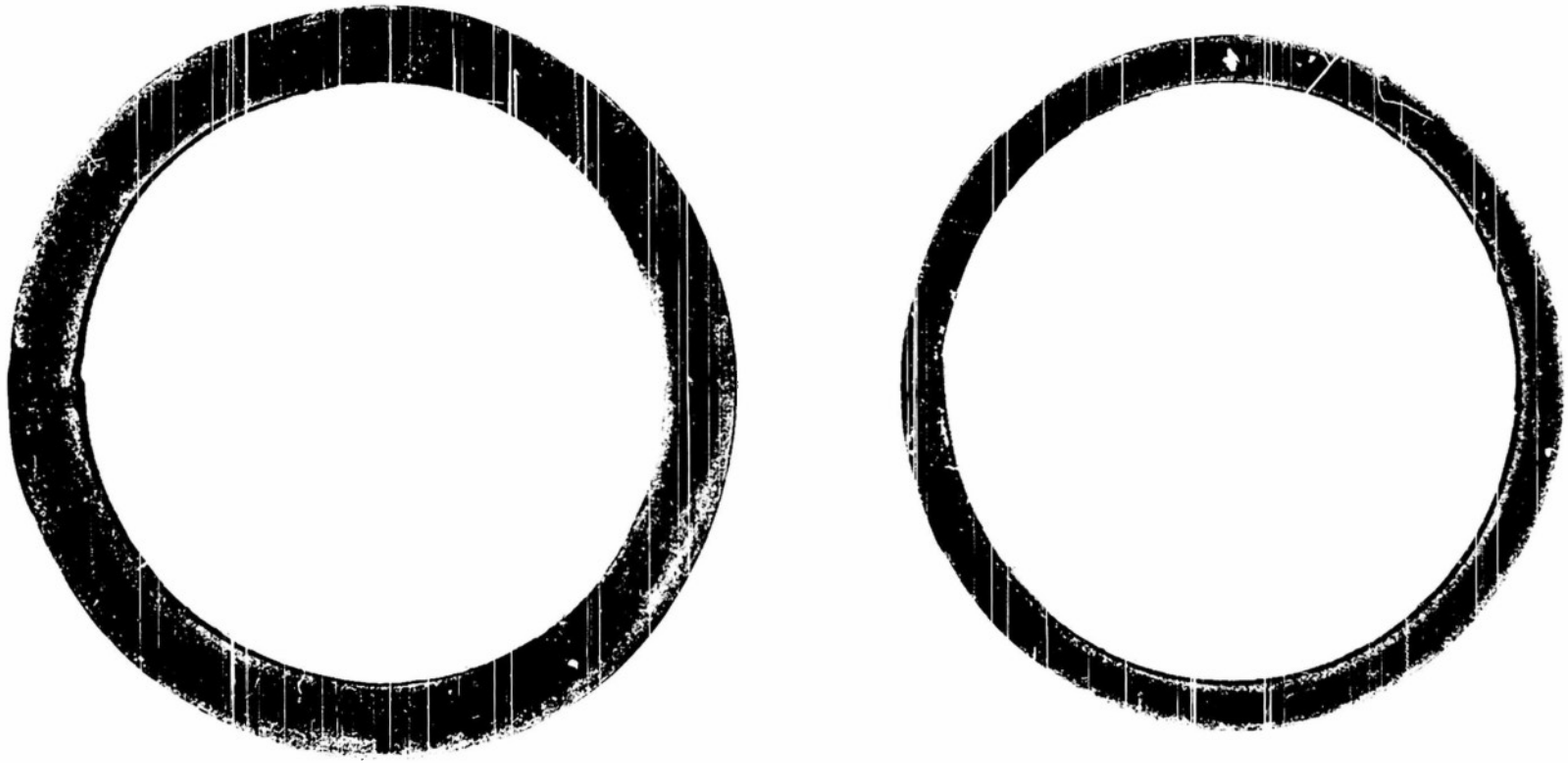
(A) NP9-49150 100X
Weld metal - note the stringers of iron oxide inclusions.
ASTM Grain Size No. 1 Nital Etch

(B) NP9-49151 100X
Coarse ferrite grains in the heat-affected zone.
ASTM Grain Size No. 2 Nital Etch

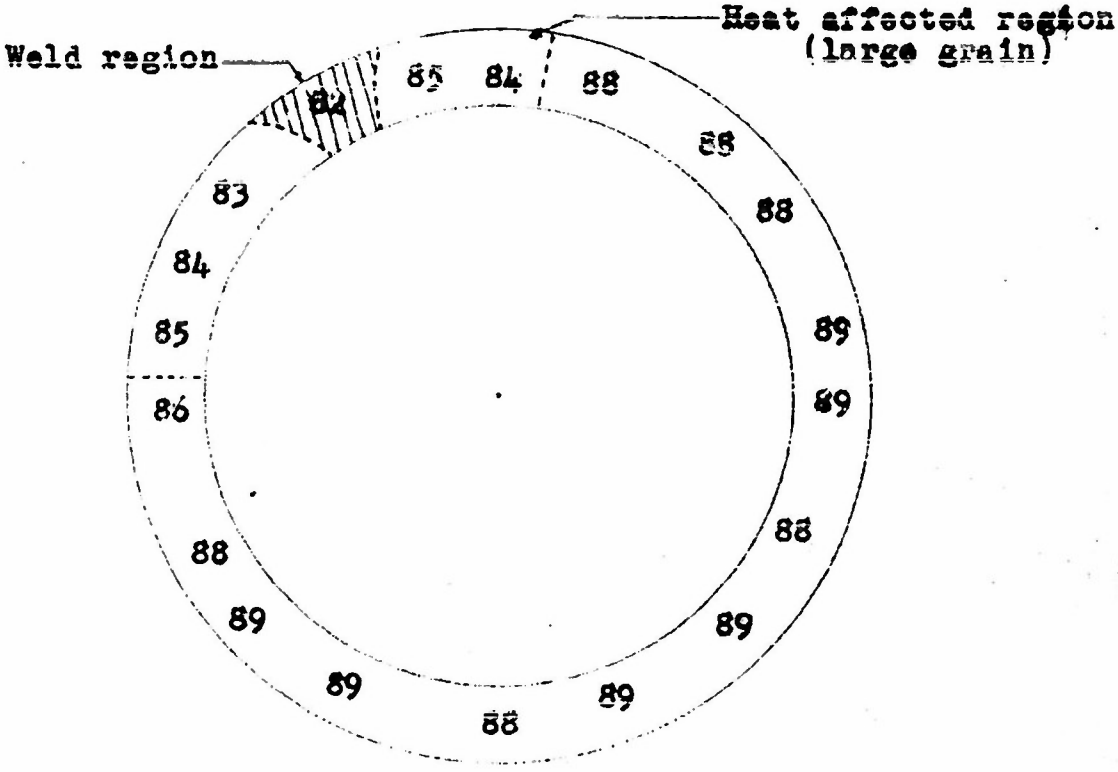


(C) NP9-49152 100X
Normal ferrite polyhedral grains in the non-heat-affected base metal.
ASTM Grain Size No. 4 Nital Etch

Microstructures in the 3"/70 Welded Tube Rotating Band.

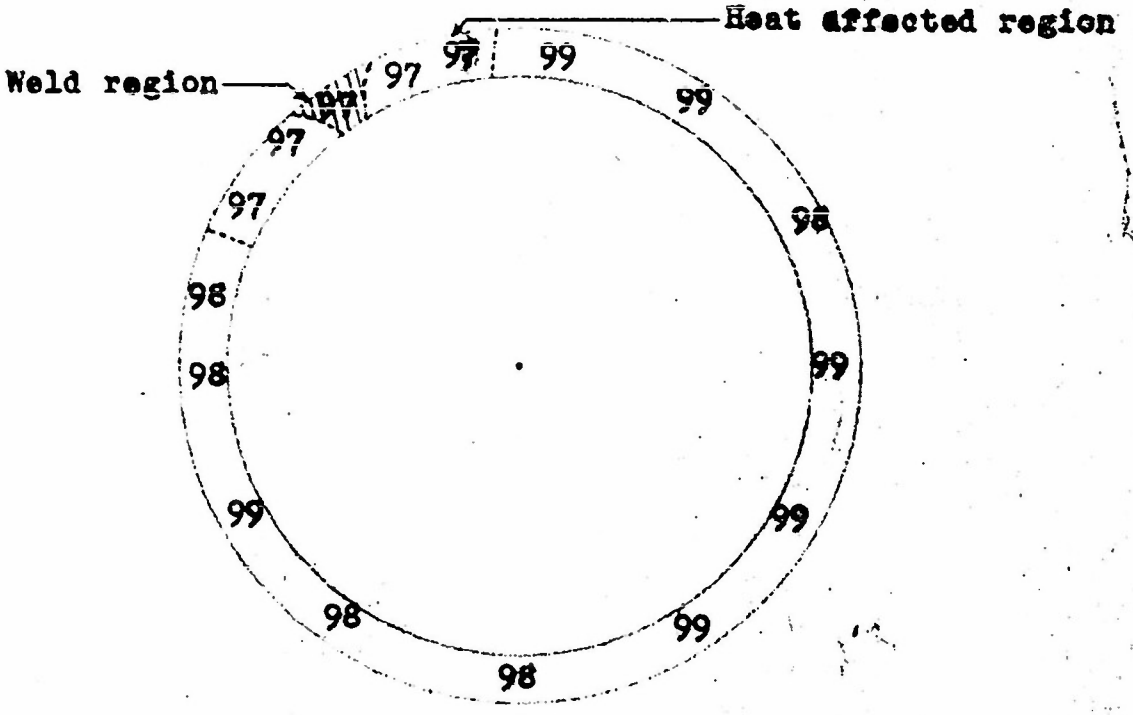


Macrospecimens of the 3"/50 and 3"/70 band blanks cut from welded tubing.
Figure 29



3"/70 Welded Band Blank

Rockwell "F" Scale 60 kg. Load - 1/16" Ball



3"/50 Welded Band Blank

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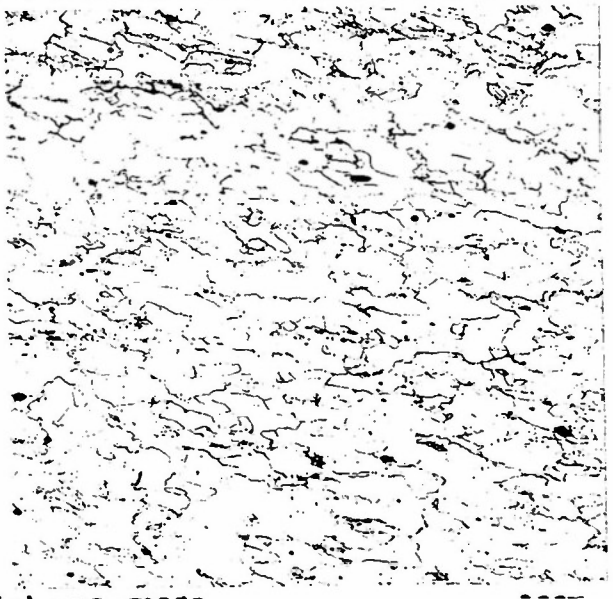
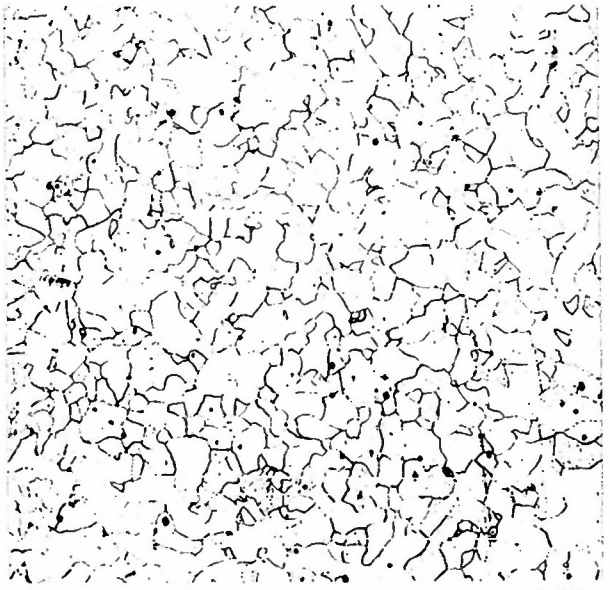
Hardness Distribution of Iron Welded Tubing, Before Heat-treating.

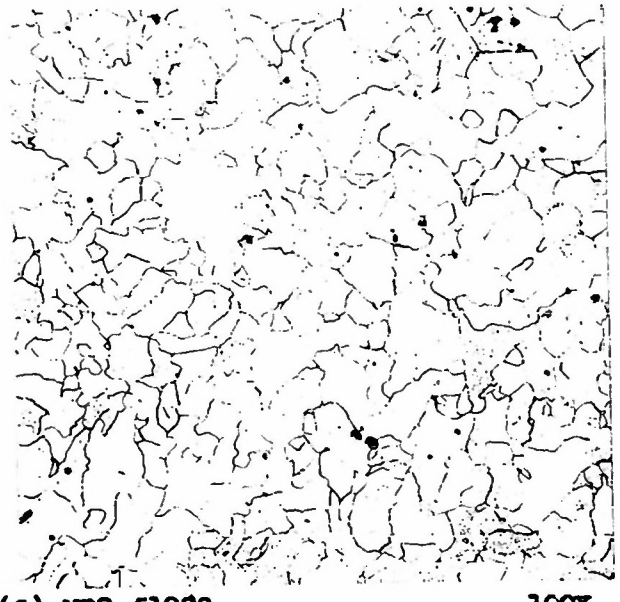
Figure 50



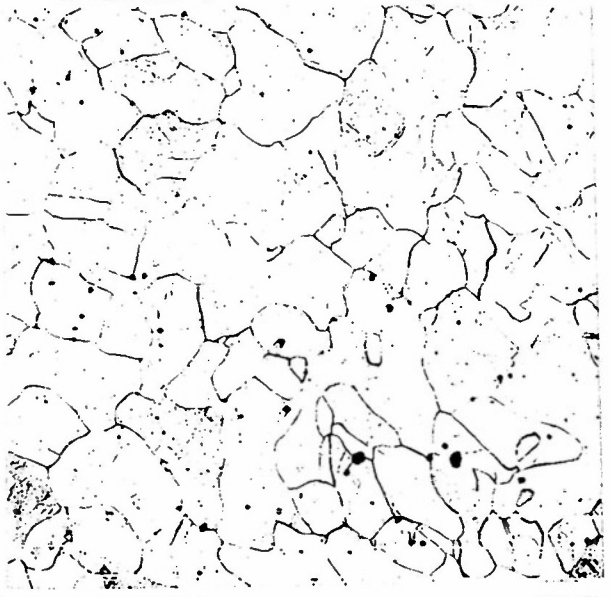
(A) NP9-51982 100X
3"/50 welded tubing in the as received condition. Nital Etch.



(B) NP9-51981 100X
3"/50 welded tubing after heat-treatment. Nital Etch.

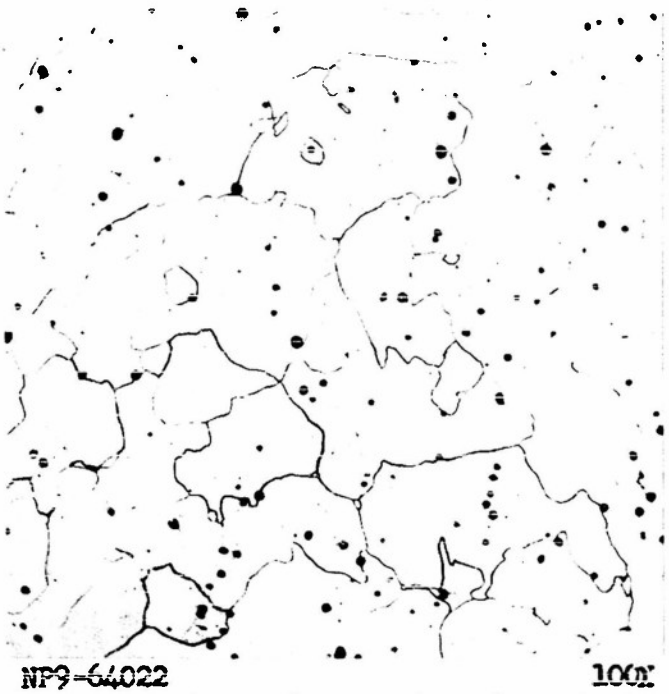


(C) NP9-51983 100X
3"/70 welded tubing in the as received condition. Nital Etch.

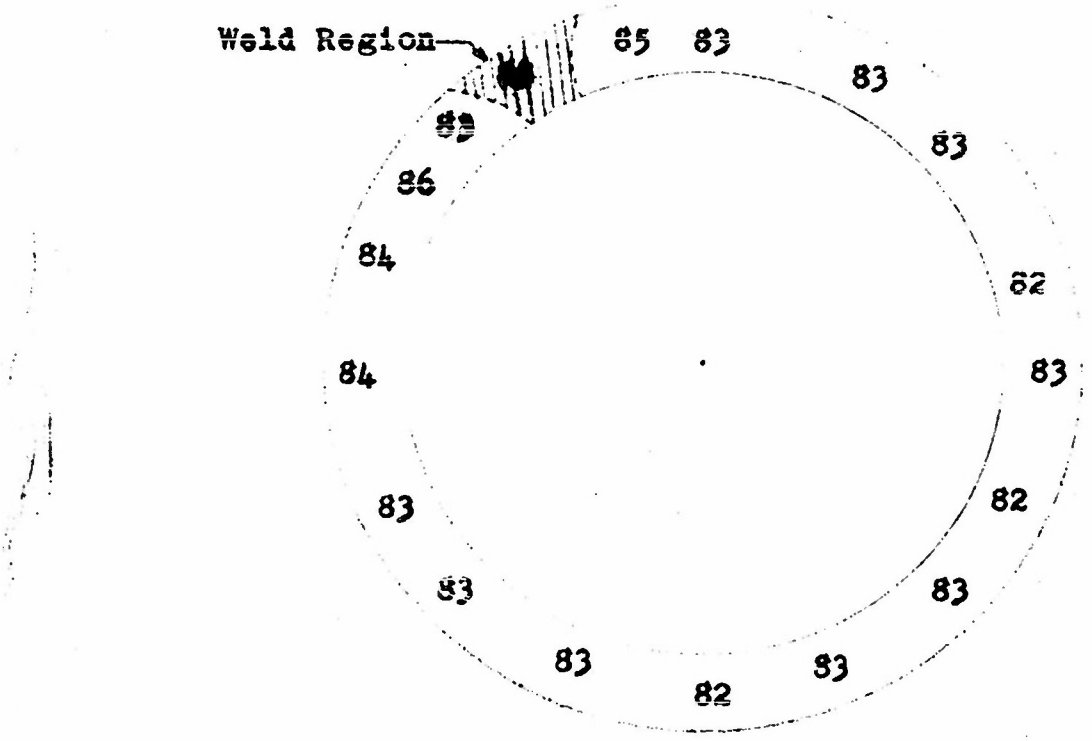


(D) NP9-51984 100X
3"/70 welded tubing after heat-treatment. Nital Etch.

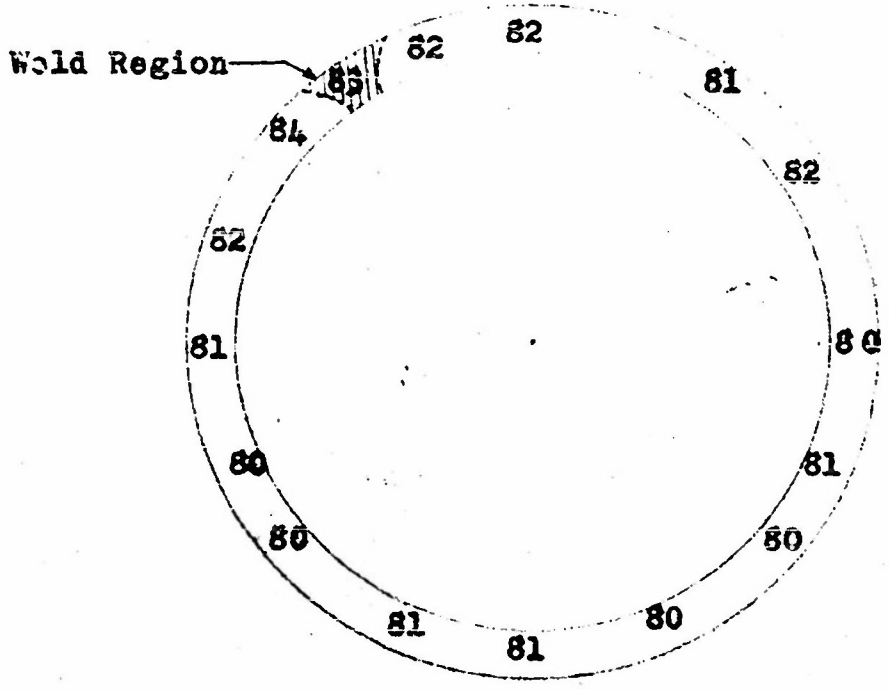
Microstructures of the Welded Tubing in the As-received and Heat-treated Conditions.



NP9-64022 100X
Microstructure of Armco iron bar stock, as received. Nital Etch.



3"/70 Welded Band Blank
Rockwell "F" Scale 60 kg. Load - 1/16" Ball



3"/50 Welded Band Blank

APZ-179

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Hardness Distribution of Iron Welded Tubing, After Heat-treating.
Figure [redacted]

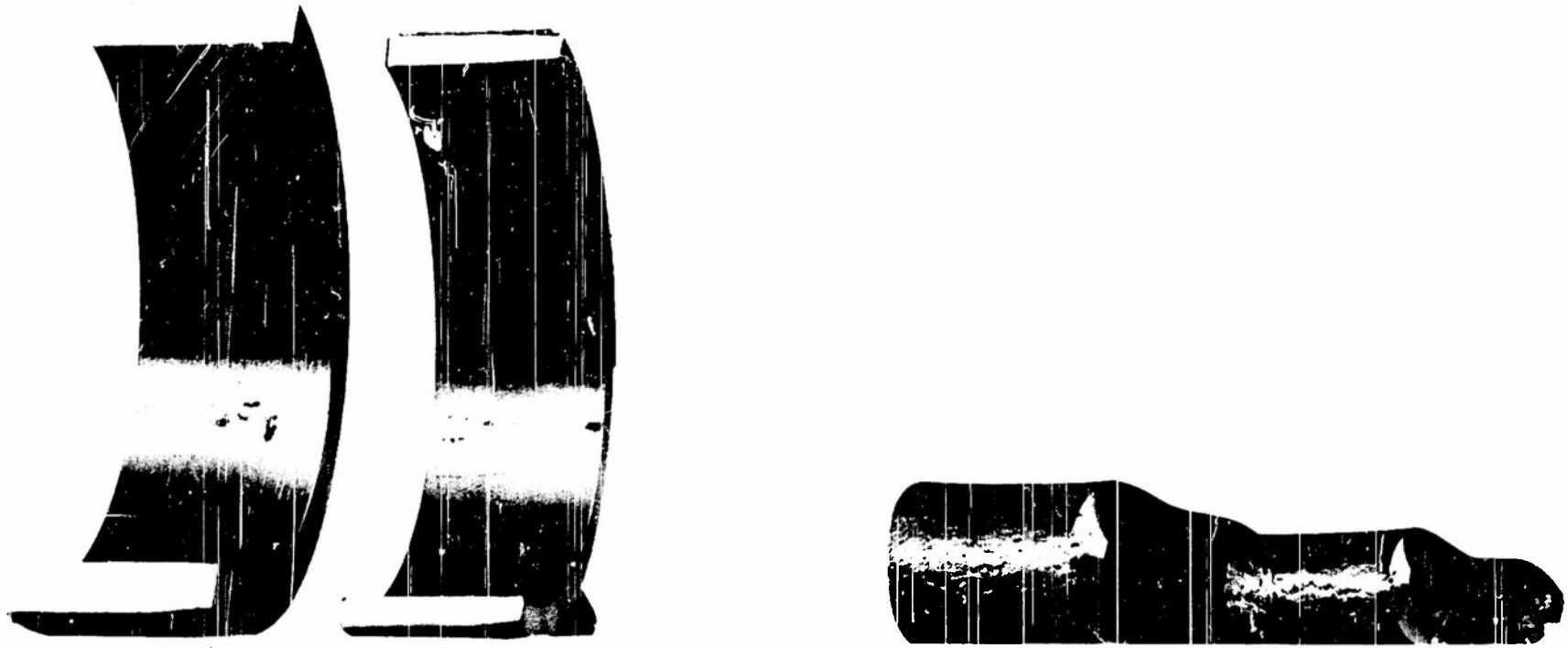

Figure 34

NP9-51985
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Photograph of the 3"/50 and 3"/70 band blanks obtained from welded tubing, before (left) and after (right) bend test.

APPENDIX E

WIRE IMPRESSION METHOD OF DETERMINING SPIN

Two screens are set up 41⅓5 apart, each screen consisting of a metal frame with wood insets, holding an array of parallel equidistant vertical copper wires. The spacing of the wires is 1/2" for the first screen and 3/4" for the second. The projectile is fitted with a flat-nosed dummy nose plug or the equivalent, so that after passing through the screens it bears two sets of impressions of the wires. The angle between the two sets of impressions is measured and from this measurement the rifling of the gun, the muzzle velocity, and the velocity at the spin screens, is computed the percentage of nominal spin. It is assumed that over the short distances involved the spin retardation is negligible.

APPENDIX F

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Subject: Ballistic and Metallurgical Tests of Welded Ingot Iron Tubes by H. L. DeRocher and W. T. Highberger, Terminal Ballistic Department, U. S. Naval Proving Ground, Dahlgren, Virginia 30 July 1954

ABSTRACT

Before an adequate number of 3"/50 and 3"/70 projectiles could be obtained with ingot-iron bands for gun wear tests, a method of fabricating iron band blanks in quantity was needed. An investigation of the properties and performance of band blanks cut from welded tubing that had been formed from Armco iron plate stock is reported here. Four 3"/70 Projectiles Type Ex 24 Mod 11 and four 3"/50 Projectiles Type Ex 29 Mod 1 with iron bands fabricated by this method were fired for recovery along with comparison projectiles having iron bands machined from bar stock. A series of metallurgical tests was conducted to explore the properties of the welded iron tubing. Both the recovery firing and the metallurgical tests indicated that the ingot-iron band blanks cut from welded tubing are essentially comparable with the blanks machined from bar stock.

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